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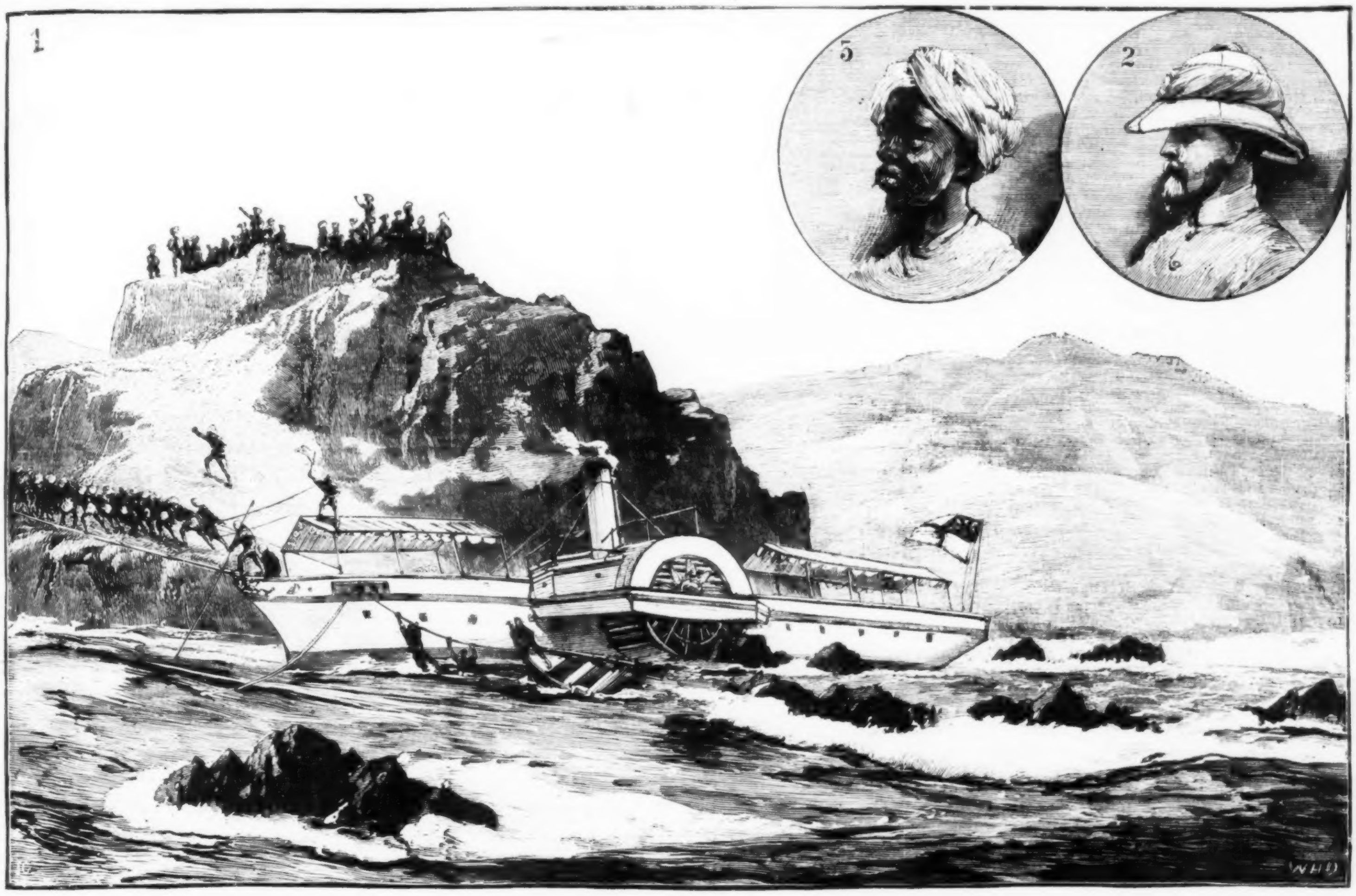
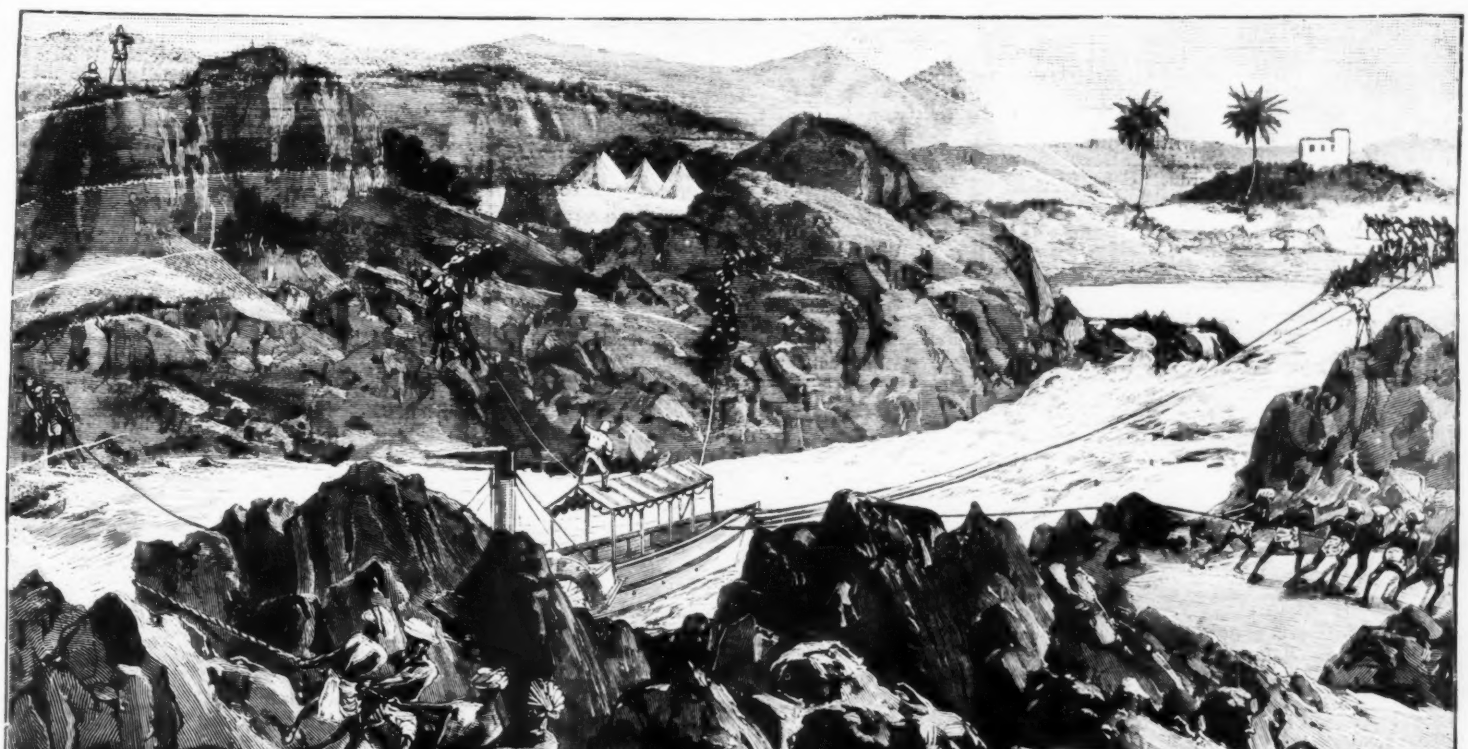




THE ENGLISH NILE EXPEDITION.—THE NASSIF-KHEIR PASSING UP THE BAB-EL-KEBIR, THE "GREAT GATE" OF THE SECOND CATARACT.

THE NILE EXPEDITION.

Our special artist, Mr. Melton Prior, who accompanies Lord Wolseley's military expedition up the Nile, has sent us two sketches from Assiout, in Upper Egypt, where the railway from Cairo terminates, 250 miles above the capital city, and where the troops, the stores, and the small boats sent out from England are put on boord steamers for conveyance to Assouan, the head of ordinary steam navigation below the rapids of the first cataract. Assiout, of which town he presents an effective general view, is situated a mile from the river-bank, on a small island connected by an arched stone bridge with the western mainland, below a hill or mountain which was, in the early ages of Christianity, the abode of numerous hermits and refugees from persecution; the grottoes in which they dwelt, and the tombs in which they were buried, are still to be seen. The town is a place of considerable trade, being connected by the Bahr Yusuf Canal with the fertile lake district of the Fayoum, and it has 25,000 inhabitants, with two fine mosques surmounted by minarets, a palace for the provincial governor, a college, bazars, baths, and some well-built houses; the manufactures of linen and woolens, pipe bowls and pottery, are much esteemed. The port of this town is El Hamra, where all the Nile steamers land or embark either passengers or cargo; and it is here that the English-made boats are shipped for transport to the higher region of the Nile.

We have also received from an officer employed with the advanced guard of the expedition, beyond Wady Halfa, some additional sketches of the difficult passage of the second cataract by the steam boat Nassif-Kheir. To the upper engraving are appended the portraits of Lieutenant Poore, R.N., commanding the steamer, and of Coki, the chief of a tribe of Nubian Arabs employed to help at the Cataracts, the best swimmer on the Nile, and a most useful and trustworthy man. In the other illustration, General Sir Evelyn Wood stands on the top of a high rock at the left hand, with his aide-de camp, overlooking the passage of the Bab-el-Kebir, the "Great Gate" of the Cataract. What is called the Cataract must be understood as rather a succession of rapids flowing between the rocks in the channel of the river. The following description is taken from a letter of the *Standard* correspondent: "From Wady Halfa upward, for many miles above the second cataract, the Nile is simply a succession of these rapids. We surmount one, and in half an hour have to contend with another. During high Nile many of these are, of course, completely submerged, but as the river falls, more and more of them appear, until at last it becomes impossible even for a nugger to ascend. We are now almost at the end of the navigable season, and are experiencing the Nile at its worst. After a time it is possible to comprehend the system by which the boatmen navigate, although at first it seems highly bewildering, and to the novice alarming. Every rapid has its slack water, sometimes on one side of the river, and sometimes on the other. When we get to the end of one stretch, we shoot across the stream to the other, and so gradually ascend, as if by so many locks. The dangerous period, of course, is when striking across, as the boat is then carried rapidly downward, and if it should fail to reach in time the friendly eddy on the other side, might be dashed against the rocks that lurk under water, and so be wrecked. One thing is certain: small boats such as those coming from England will not be able to sail up the rapids after the manner described above. In the first place, they will not have enough sail-power; and in the second, they will not be large enough or strong enough to swim in mid-stream or to cross from eddy to eddy. They must be hauled up close in shore, which in many places is no easy task, owing to precipitous banks and overhanging trees. If the pioneer craft carried a number of gun-cotton cartridges, many of these obstacles might be blown away; but in any case, to drag the boats along the Nile banks will be wearisome work. Powerful steamers might prove effective, but the period for sending powerful steamers to Dongala has now passed. Perhaps, however, as some assert, the Nile will be easier for small craft when at its lowest. Semneh, eight miles from Sarras, was reached on the third day. The cataract here is to some extent worthy of the name. The river evidently passes over a ledge of rock deep at the bottom, but still sufficient to cause a fall, over which the boats have to be hauled by manual labor. Here three hundred of the Mudir of Dongola's men are stationed for the work, and as we showed round the bend of the river they swarmed down to the beach to meet us. The boat was lightened of most of its cargo, and then, laying on to a hawser, some two hundred yards long, and shouting and singing, the noisy half-naked mob soon pulled her over the fall. The Semneh Cataract, though honored with a place on the map, will not prove so serious an obstacle to the expedition as the nameless rapids described above."

Lord Wolseley's army, possibly, may have no fighting to do when it gets up the Nile; but General Gordon is actively engaged in river steam-boat expeditions to drive his enemies out of the towns and villages below Khartoum, some of which he has bombarded. The engraving presented for our extra supplement is designed to show the probable character of such incidents; and that entitled "An Ambush of Arabs" will serve to illustrate the nature of guerilla warfare in the Soudan.—*Illustrated London News.*

[From the London Graphic.]

GENERAL VIEW OF CAIRO.

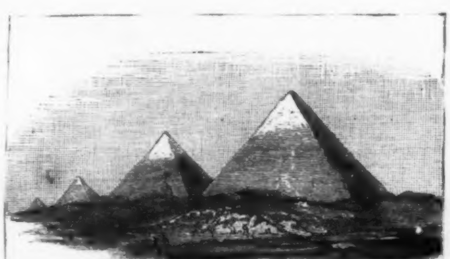
This panorama of the Nile from Cairo to Khartoum is intended as an illustrated itinerary of the route to be followed by the Gordon Relief Expedition, under Lord Wolseley. Owing to the exigencies of space, our artist has been compelled to straighten the great bends which the river makes at certain points. But a note to this effect will be found at each bend. With regard to our illustrations, we have to acknowledge our indebtedness to George Ebers' "Egypt" (Cassell & Co.), several fine water-color drawings by Mr. Frank Dillon, sketches by our special artist, Mr. Frederick Villiers, and Colonel the Hon. J. Colborne. Cairo is the capital and largest town in Egypt, and since September 14, 1882, when General Drury-Lowe, with a handful of troops, after the battle of Tel-el Kebir, demanded and obtained the surrender of Arabi Pasha, the town has been occupied by a British garrison. By the Arabs Cairo was called Masr-el-Kaherah, and the present city was founded on the site of Babliam, a colony from Babylon, in 969, and in former years supplanted Fostat as the capital of Egypt. The city now contains a population of 327,462 souls. The distance from Cairo to Khartoum is 1,645 miles, and the railroad runs only to Siout, a distance of 229 miles. Thence the journey will have to be made in small boats.

OLD CAIRO.

"OLD CAIRO" is situated about three miles from Cairo proper, and is the ancient city of Fostat, founded by the Arabs in 638, under Amer ibn el As, who conquered Egypt in the khalifate of Omar. The mosque founded by him still bears his name, and the town is said to have been called from his battle tent (fostat). When Gowhor-el-Kaed founded modern Cairo (Masr-el Kaherah), in 974, Fostat sank into comparative obscurity, and was then denominated Masr-el-Ateeka, or Old Masr. This has been changed by Europeans into Old Cairo.

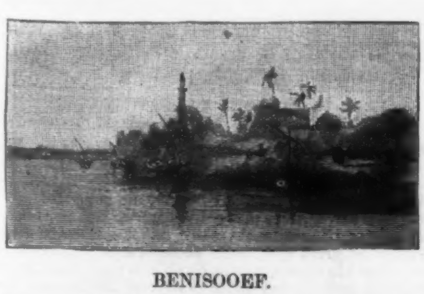
GHIZEH.

GHIZEH is one of the ruined places of Egypt. Once it was a fortified place, a busy commercial center, with thriving markets and crowded mosques. It was the summer retreat of the Mamelukes and Caireues, but now contains only a few cafes, decaying bazars, and ruined houses. The road from Cairo to Ghizeh is for some distance the same as that to Old Cairo; it then turns to the right to Kasr-en-Neel, and crosses the river over an iron bridge above Boulak. Ghizeh is but a drive of an hour and a half from Cairo.



THE PYRAMIDS OF GHIZEH.

THESE are three in number, and they are the tombs of three kings of the fourth dynasty—Cheops, Chephren, and Mycerinus. The Great Pyramid is 460 feet high (or sixty feet higher than the cross of St. Paul's), and in area it is about equal to Lincoln's Inn Fields. The Great Pyramid has been the plaything of many theorists, of whom Professor Piazzi Smyth is the best known. This writer maintains, with much ingenuity and earnestness, that the Pyramid of Cheops is a vast monument specially erected, B.C. 2170, to perpetuate a certain system of weights and measures. What is commonly called the sarcophagus of Cheops in the King's Chamber is, says Professor Smyth, a coffer equivalent to the laver of the Hebrews. It is remarkable that four English quarters (the largest measure of wheat used in this country) exactly fill the coffer in the King's Chamber.

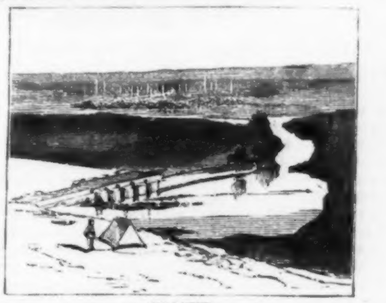


BENISOOEF.

BENISOOEF is a large and important town, seventy-three miles from Cairo. It is the capital of the province, and the residence of the Mudir, or Governor. There is a railway station and a good bazar. The population is about 5,000. The chief industry is the manufacture of woolen carpets and warm linen stuffs. Indeed, this industry dates from early times, as in the days of Leo Africanus Benisooef was famous for its linen fabrics, and supplied all Egypt with flax, besides exporting great quantities. The industry was revived by Mehemet Ali in 1826.

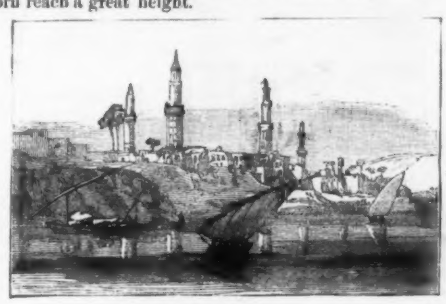
MINIEH.

MINIEH is a flourishing town, the capital of the province of the same name, and is situated on the left bank of the Nile. It is 160 miles from Cairo by water and 151 by rail. Like Benisooef, Minieh was a prosperous town in the time of Leo Africanus, who states that it was built in the time of the Moslems by Khasien, who was appointed Governor under the khalifate of Bagdad. The great industry is that of sugar, the first sugar factory in Egypt having been built there. During the sugar-cane harvest, and when the mills are in full activity, the town presents a very lively appearance. The sugar estate is the most extensive in Egypt, consisting of 30,000 acres, 2,000 of which are planted with sugar-cane—the rest fallow or with cereals. "The estate and factory," writes Mr. Villiers Stuart, M.P., "is beautifully managed, and there is no forced labor." There are also other large private properties



SIOUT.

AT a later time they were the refuges of Christian monks and hermits, like those described in Charles Kingsley's novel, "Hypatia." Such towns as Siout are merely magnified specimens of the ordinary Egyptian villages. The houses are of mud-bricks, and are seldom more than one story high. Their fronts have no windows, and are without ornament, and all are thrown together without any attempt at methodical arrangement. Streets are vaguely defined, and as several houses are always in ruins, the breaches thus made are used as convenient short-cuts from place to place. In most streets, however, there is a causeway raised above the reach of inundations. The soil round Siout is extremely rich, and the crops of clover, beans, and corn reach a great height.



GIRGEH.

ONE of the chief causes of the decay of Girgeh is the encroachment of the Nile, which has completely eaten away its banks. The houses have partly fallen over the edge; and now there is room for only a single donkey to pass between the town and the precipitous bank over which the passer-by can look perpendicularly on to the decks of the Nile boats moored below. "Dilapidated as it is," writes Mr. Stanley Lane Poole, in his admirable little handbook on Egypt, "Girgeh is exquisitely situated, and faces a glorious cliff of the Arabian mountains, and its large Copt population keeps up a fair amount of industry, and dyers and goldsmiths do a considerable trade." The washing away of the banks of Girgeh, which was once a quarter of a mile from the river, is yet another proof of the great changes which have taken place in the course of the river, and explains the apparent errors of the ancient geographers, who laid down many towns now on the banks of the Nile as being some distance inland.

DENDERAH.

THE beautifully preserved ruin of the Temple of Denderah, 406 miles from Cairo, although comparatively modern, being in no part earlier than the time of Ptolemy Antetes in the first century B.C., is one of the most interesting ruins in Egypt. It is a remarkable specimen of the persistence of the Egyptian style. Its construction was completed under Tiberius, and its decorations under Nero, so that the Temple was being built while Christ was living at Jerusalem. From the river-bank there is a ride of three-quarters of an hour to the ruin, and on crossing from Keneh the traveler is met by the usual impatient and noisy men and boys with donkeys, clamoring for custom. On entering, the traveler finds himself in the great hall or portico, with its twenty-four columns.

THE NILE NEAR THEBES.

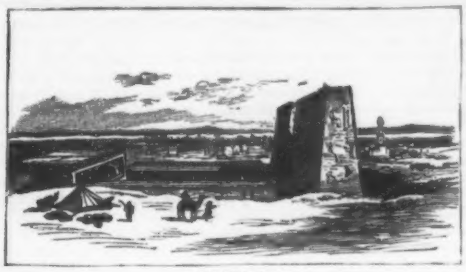
THE temples of Luxor and Karnak on the other bank then remain. Thebes was one of the most splendid cities of the ancient world. Homer's epithet of hundred gated Thebes seems scarcely accurate, since Thebes was never inclosed by a wall; but it has been suggested that the "gates" were the propylæa of the temples. An ancient writer says that Thebes and the vicinity could furnish 20,000 armed chariots, and the splendid remains of the city attest its ancient magnificence. "Alone of the cities of Egypt," says the late Dean Stanley, "the situation of Thebes is as beautiful by nature as by art. The monotony of the two mountain ranges, Lybian and Arabian, for the first time assumes a new and varied character. They each retire from the river, forming a circle round the wide green plain; the western rising into a bolder and more massive barrier, and inclosing the plain at its northern extremity as by a natural bulwark, the eastern further withdrawn, but acting the same part to the view of Thebes as the Argolic mountains to the plain of Athens, or the Alban Hills to Rome."

VILLAGE OF KARNAK.

KARNAK is a collection of temples grouped round a chief temple; and the buildings are principally of the great epoch of the Eighteenth to the Twentieth Dynasties, though earlier portions (of the Twelfth) and late Ptolemaic additions can be distinguished. Luxor is the anchoring place for Karnak, and from one place to the other the road lies over a grassy plain. "We rode," says the author of "The Crescent and the Cross," "along a wide plain covered with coarse grass, and varied by some gloomy little lakes and acacia shrubs, when, at the end of an hour, our guide reined in his horse, and pointed with his spear toward the south. There lay Karnak—darkening a whole horizon with portals, and pyramids, and palaces. . . . It must have been a noble sight in the palmy days of Thebes—that avenue of two hundred enormous statues, terminated by that temple. Yet this was only one of many; at least seven others, with similar porticoes and archways, led from this stupendous edifice. We rode through half a mile of sphinxes, and then arrived at the temple, the splendor of which no words can describe."

ESNEH.

ESNEH, known as the healthiest place in Egypt, is 484 miles from Cairo, and has not unjustly been termed "the most picturesque and amusing city on the Upper Nile." The air is considered exceedingly good for invalids, who are constantly sent from Cairo and Alexandria. It will thus not improbably serve as a useful sanatorium for our sick troops. The town contains a population of 7,000, and is a busy, thriving place, carrying on a considerable trade in cereals with the Soudan, in exchange for the products of that country. There is a noteworthy temple in the middle of the town, the portico of which, cleared out by Mehemet Ali on his visit in 1842, is the only part visible. Whatever may have been the date of the inner portion of this temple, remarks the writer of Murray's Handbook, the portico merely presents the names of some of the early Cæsars. Mention is also made of Thothmes III., by whom the original temple was perhaps founded.



EDFOU.

THE village of Edfou, 514 miles from Cairo, is about half a mile from the river side, and is chiefly noteworthy for its temple. It was practically excavated from a mound of rubbish, by Mariette Bey in 1864. This temple was founded by Ptolemy Philopator, and was completed by his various successors. The whole length is about 450 feet, and the breadth 250 feet, and the plan resembles that of Denderah. There are two magnificent propylon towers, and the temple contains three halls, the pillars of which are in admirable preservation. The sculptures with which every part of the temple is covered are extremely interesting, and many contain valuable information respecting the ancient geography of Egypt. By means of some inscriptions, also, which give the dimensions of the various chambers, the ancient Egyptian measurements can be compared with those of modern times. The neighborhood of Edfou teems with game during the winter months, the sand banks in the river being frequently covered with aquatic wild fowl.

THE FIRST CATARACT.

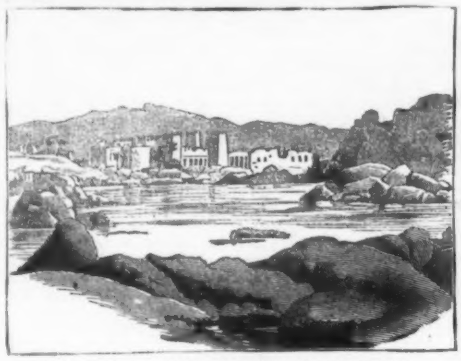
THERE is a general impression that the Nile Cataracts are species of miniature Niagaras, whereas they are really little more than a succession of rapids, whirlpools, and eddies caused by rocks and islets. At high Nile all but the tallest rocks are covered with water, and then it is possible for boats to sail up what is practically little more than a very powerful stream. As the river falls, however, it becomes divided into numerous narrow channels, which necessitate the boats being towed through the rapids and falls which are then produced. The First Cataract, or Cataract of Assouan, is from two to three miles long. Both dahabeahs and nuggars (smaller Nile boats) pass with their cargoes at high Nile. At low Nile, when ascending and descending, they usually discharge cargo. The gradient is not more than one in fifteen.

FRONT OF THE SMALL ROCK TEMPLE AT ABOU SIMBEL.

NEAR the Great Temple is the smaller one, of whose front a view is given above. This temple is dedicated to Athor. It also is excavated in the rock, and in front has seven large buttresses sloping backward from the base, with six standing colossi between them. The interior contains a hall with six side chambers, but the sculptures and decorations are much inferior to those in the large temple. Opposite Abou Simbel, at Ferayg, is a small temple containing Egyptian sculptures and Christian symbols. Ordinary tourists seldom penetrate far beyond Abou Simbel. The Nile scenery here becomes tamer, and the frequent rapids render navigation tedious, and not a little dangerous.

FRONT OF THE GREAT TEMPLE AT ABOU SIMBEL.

THE Great Temple, 756 miles from Cairo, forms the leading attraction of the Upper Nile. The interior vast hall, carved out in the living rock, is wonderful enough. Its proportions are gigantic, and it is supported by eight Osiride columns, *i. e.*, columns with the head and figure of Osiris, as at the Rameseum. The great marvel of all, however, is the outside, where, cut from the face of the rock, four gigantic figures of great Rameses II. are sitting side by side, in a sublime repose, upon their thrones. Their total height is given at sixty-six feet. A great part of one of them, however, has been shamefully wedged out and thrown down. Everybody has remarked upon the excessive sweetness of the expression of these faces, which, taking into consideration their enormous size—the ear measuring three feet five inches—is miraculous; and the flat, open hands, laid out upon the knees, impart a very magic of placidity. They look calmly out over a very broad part of the river. At night the scene far surpasses that by day.

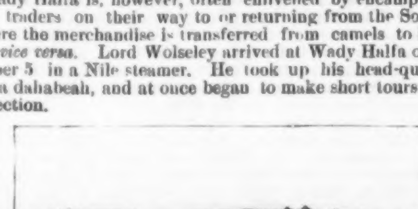


VIEW OF PHILÆ FROM THE NORTH.

G. FLEMING, in "A Nile Novel," thus describes the scene at Philæ: "On either side high walls of overhanging rocks shut in the river, standing in pious guardianship around the sacred isle. Beneath their frowning blackness lapsed and flowed a wide, shining expanse of water, stained crimson with the sunset's glare; beneath, a line of tall and plumy palms were bending in the wind; to the east the Libyan sands poured in a golden stream through every cleft and fissure in the darkling hills; and overhead and all about floated a splendor of reddening fire. From their station on the pylon they seemed to look straight into the heart of the sunset, where all the west had burst into sudden flames of fire. The freshening wind blew to them in uncertain rise and fall; the melancholy sound of the distant cataract, and now and then the cry of some nightbird, cut sharply through the stillness of the hour. An immense sense of loneliness brooded over the empty temples and the silent islands, abandoned by their forgotten gods, whose sculptured faces mournfully gazed out from the crumbling walls, flushed by the supreme splendor of the dying day."

WADY HALFA

Is 798 miles from Cairo, and is a large village lying scattered among a thick belt of palms. It is a place of much importance in connection with the expedition for the relief of General Gordon, as it practically forms the base of operations From Philæ to Wady Halfa the troops will be transported by boats. From Wady Halfa a railroad about thirty miles long turns a portion of the second cataract, and strikes the Nile at Sarras. The town is somewhat picturesque, but the surrounding country is drear and desolate. Wady Halfa is, however, often enlivened by encampments of traders on their way to or returning from the Soudan. Here the merchandise is transferred from camels to boats, or *vice versa*. Lord Wolseley arrived at Wady Halfa on October 5 in a Nile steamer. He took up his head-quarters in a dahabeah, and at once began to make short tours of inspection.

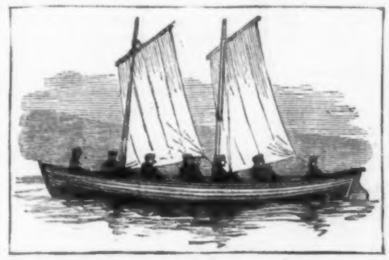


ABOU HAMAD.

FROM the third cataract to Abou Hamad (1,297 miles from Cairo) the Nile makes a large, right-angled bend, which we are unable to represent upon this map. Proceeding up stream, the island of Argo is first passed, and then the town of Ordee, or New Dongola, is reached. It is the capital of Lower Nubia and the residence of the Mudir, whose loyalty to the British during the Soudan rebellion has been so repeatedly questioned. New Dongola is an insignificant place; and the traveler next reaches Old Dongola and Debbah. From Debbah is a direct road across the desert to Khartoum, a ten days' journey. After Debbah the next important place is Ambukol, whence a desert route to Shendy cuts off another bend in the Nile. It is not unlikely that Lord Wolseley's Camel Corps will be dispatched by this route. After Ambukol comes Merawi, whence there is a direct route to Berber. Soon after passing Merawi there is a stretch of 140 miles impassable at low Nile, and only passable for small boats at high Nile. There are in this district some seven distinct cataracts, sometimes known as the Cataracts of Shakoujeh.

THE ROCK OF ABOUSER.

FROM the rock of Abouser, 300 feet high, and about six miles from Wady Halfa on the west bank, there is a fine view of the second cataract, with its numerous black shining rocks dividing the river into endless channels Some of the islets are merely stones; others are true islands with a surface of sand on the rocks, and fringed with trees. Five of these islands are inhabited. At the Rock of Abouser visitors are accustomed to carve their names, and the traveler may see the names of Burckhardt, Belzoni, Lord Lindsay, Warburton, and others



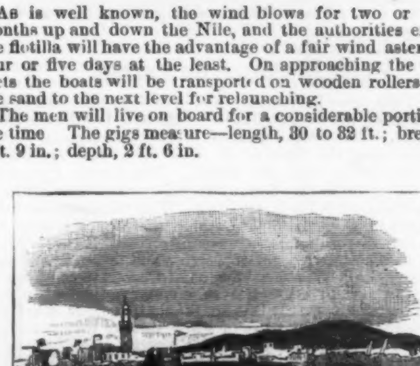
BOAT FOR THE NILE EXPEDITION UNDER SAIL.

As soon as the authorities had finally made up their minds to send a flotilla of boats to Cairo for the relief of Khartoum, not a moment was lost in issuing orders to the different shipbuilding contractors for the completion, with the utmost dispatch, of the 400 "whaler-gigs" for service on the Nile. They are light-looking boats, built of white pine, and weigh each 920 pounds, that is, without the gear, and are supposed to carry four tons of provisions, ammunition, and camp appliances, the food being sufficient for 100 days. The crew will number twelve men, soldiers and sailors, the former rowing, while the latter (two) will attend the helm. Each boat will be fitted with two lug sails, which can be worked reefed, so as to permit an awning to be fitted underneath for protection to the men from the sun.

BOAT FOR THE NILE EXPEDITION, SHOWING AWNING.

As is well known, the wind blows for two or three months up and down the Nile, and the authorities expect the flotilla will have the advantage of a fair wind astern for four or five days at the least. On approaching the Cataracts the boats will be transported on wooden rollers over the sand to the next level for relaunching.

The men will live on board for a considerable portion of the time The gigs measure—length, 30 to 32 ft.; breadth, 6 ft. 9 in.; depth, 2 ft. 6 in.



BERBER FROM THE EAST.

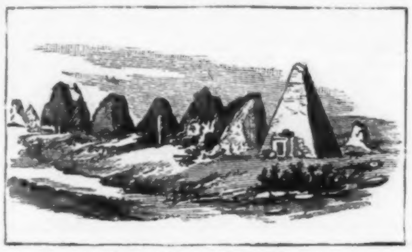
LATELY, however, General Gordon, after raising the siege of Khartoum, steamed up to Berber, bombarded the town, and drove out the rebel garrison, who succeeded in escaping with the treasure. Once at Berber, the main difficulties of Lord Wolseley's river expedition will be at an end, for from Berber to Khartoum there are but 204 miles of river, which offer no great difficulties to navigation, and General Gordon, with his steamers, will be able to meet the advancing force—if, indeed, any advance beyond Berber be necessary in the present state of affairs. Berber itself is an insignificant and unattractive Nubian town. It is the limit of the southern flight of the quail, and between it and Khartoum crocodiles and hippopotami abound. About twenty miles above Berber is the mouth of the Atbara River. The male population is about 3,000. The streets are dirty and unpaved, the houses are of sun-dried bricks. There is a small bazar, government buildings (shown in our engraving), and a telegraph office. The town is protected by earthworks 4,500 yards in extent.

SEMNEH.

THIRTY-FIVE miles beyond Wady Halfa are the village and cataract of Semneh. The cataract is not difficult, and with a fair wind nuggars can pass with their cargoes. The part of the river about Semneh is called by the Arabs Batu en Hogar, or "the Belly of Rock." On either bank are interesting temples of the third Thothmes. That on the east bank consists of a portico, a hall parallel to it, and some minor chambers. It stands in an extensive inclosure. The river can be crossed on frail rafts, made of logs lashed together, and pushed forward by men who swim behind it. The temple on the west side consists of only one chamber At Semneh north winds are prevalent.

SIOUT

Is 247½ miles by water and 229 by rail from Cairo. It is nominally within eighteen hours (336 miles) of Alexandria, and from this point steamers will without difficulty convey the troops 320 miles up stream to Assouan. Siout is the capital of Upper Egypt, contains the residence of the governor, and has a population of 25,000 souls, of whom about 10,000 are Christians. Its trade in linen, cloth, earthenware, woolen, and opium is considerable, and it is the starting-point of the caravans to Darfur and Nubia. The pipe bowls of Siout are renowned throughout Egypt. On the site of Siout once stood the ancient Lycopolis, or City of Wolves. The modern town stands more than a mile from the river, and is connected by a causeway with its port, the little village of El Hamra. The situation of the town is one of the most picturesque on the Nile valley. A spur of the Libyan hills incircles it at the back, whence a fine view of a hundred miles of the Nile valley may be obtained. In front is a curving reach of the river, while around spreads a broad green plain. The innumerable tombs, of which the Stabl Antar is the chief, are interesting from their Egyptian remains.



PYRAMIDS OF MEROE

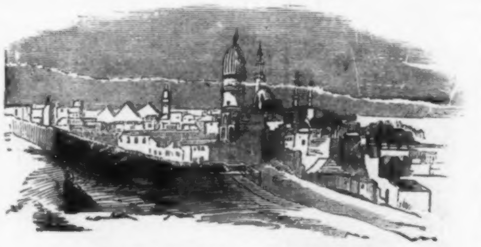
STAND on the east bank of the Nile, several miles from the mouth of the Atbara River. There are altogether about eighty pyramids, and they are distinguished from most of the other pyramids of Egypt by their projecting porticoes. These pyramids are supposed to be the burying-places of the old Kings of Meroe. The river Atbara, the most important tributary of the Upper Nile, rises in Abyssinia, and is joined by another branch, the Takazze. The Atbara is the ancient Astaborus, and it is called by the natives Bahr-el-Aswad.

GIRGEH.

GIRGEH, 341 miles from Cairo, is chiefly interesting from the fact that it contains a large Christian population, and that the town is manifestly of Christian origin. Formerly Girgeh was the capital of the province, but the town is now of small importance. It contains a Latin monastery—the oldest Roman Catholic monastery now in Egypt—Ekhmeem, Farshout, and Tahta being next in order of antiquity; but Girgeh derived its name from a Copt convent dedicated to St. George (Girgis), who is the patron saint of Egyptian Christians. This convent was one of the most opulent in Egypt, and contained 200 monks, who supplied food to all travelers, and sent large sums out of their revenue to Cairo for distribution among the poor. One year, however, the whole of the monks were carried off by the plague, and it was not until long afterward that the present convent was established. From Girgeh the excursion to Abydus may be made.

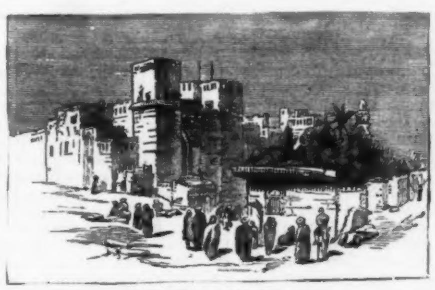
THEBES

Is 450 miles from Cairo. Abydus and Memphis are stated by Mariette to be the two most ancient cities of Egypt, as being contemporaneous with the foundation of the Egyptian monarchy; while Thebes makes her first appearance with the Kings of the Eleventh Dynasty, 3000 B.C. To give here any adequate description of the marvelous remains about Thebes is obviously impossible. At least a week must be devoted to the work if only a superficial view of the ruins is to be obtained. The village of Luxor is the best headquarters from which to visit Thebes, and the writer of Murray's "Handbook for Egypt" recommends that the ruins should be visited in the following order: Crossing to the west side of the river, the Colossi, the Memnonium, Dayr-el-Medineh, and Medinet Abou should first be inspected. Then Koorneh and the Tombs of the Kings (also on the west bank) should be visited, Dayr el Bahree and the tombs of Assaseef being taken on the way back.



CAIRO FROM THE CITADEL.

THE best view of Cairo is to be obtained from the citadel. This stronghold was built by Saladin in 1166, in order to strengthen the city. It was here, in the narrow, tortuous lane leading from one of the gates, that the massacre of the Mamelukes took place, by order of Mehemet Ali, on the 9th March, 1811. Viewed from the citadel, Cairo appears in shape an irregular oblong town, about three miles in length and two miles broad. The city, however, looks curiously vast as it lies below—a perfect wilderness of flat roofs, cupolas, minarets (there are 264 mosques and 225 "chapels" in Cairo), and palm tops. The citadel, which is built in three portions, each having its walls and towers, was occupied by General Sir Drury-Lowe upon Arabi's surrender, and has since formed the headquarters of the British garrison.



THE BAH-EN-NASR.

THIS gate, the name of which in English is "Aid to Victory," stands close to the mosque of El-Hakim. Two massive square towers flank the gateway, and above the arch are mouldings; while shields of both normal and round shapes are sculptured in relief upon the walls of the towers. At the time of the French occupation this part of the wall was utilized for purposes of defense, and the names given to the different towers may be seen cut in the stone.

DENDERAH.

THE ceiling has a representation of the Zodiac, once supposed to be ancient Egyptian, but now proved to date from Ptolemaic times. Side rooms and entrances of this stupendous ruin had each their special uses, some being reserved for royal entrances and for the robing of priests of different classes. The chambers furthest to the west formed the most sacred portion of the building. "Into the small chamber at the extreme axis of the building the king alone could enter; there, in profound secrecy, was preserved the mysterious emblem of the worship of Athor, the Life-giver, the golden *sistrum*." Other chambers were devoted to the worship of Isis, Osiris, Pasht, Horus, etc. The ancient city of Tentyris (modern Denderah), built of Nile mud, like an Arab village, easily fell to pieces, while the stone temple remained intact.

MANFALOUT

Is a town of the province of Minieh. It stands on a pretty reach of the Nile, and the first sight of the picturesque town on rounding the bend in the river is pleasant. Manfalout has two Coptic churches, woolen manufactories, and a public school, and was formerly a place of some commercial importance. It is still the residence of a Governor, and has a Sunday market; but part of the town has been washed away by the Nile, though measures have been taken to prevent this in future. On the opposite bank of the Nile are the cliffs of Abu-Feyda and the famous crocodile mummy-pits of Maabdeh, where the reptiles abounded in thousands. Several lives have been lost by suffocation in these caves, which scarcely repay a visit. The caves contain thousands of crocodile mummies and several human mummies, some gilded from head to foot.

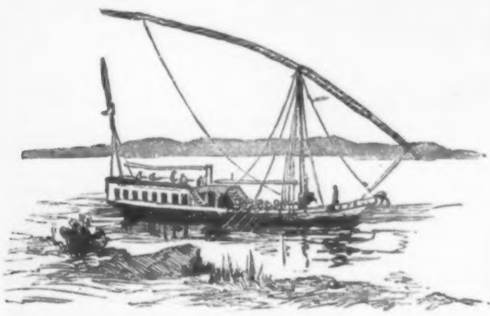
THE GREAT SPHINX.

THE Great Sphinx stands a quarter of a mile from the Great Pyramid, and guards its platform. Its intent has never been understood; but the Sphinx was a common Egyptian symbol of power—intellect joined with strength. Its features are those of the Copt, and the usual Abyssinian head-dress of to-day gives an outline precisely similar to the drapery round the Sphinx's head. It is hewn out of the solid rock, and between the monster's paws once stood a temple, believed to be older than the Great Pyramid. To-day the Sphinx's features are much mutilated, but in spite of the loss of helmet, nose, and beard, it remains the most impressive monument in the world. The Sphinx is not mentioned by any author or traveler before the Roman period, but Pliny gives a long account of it.

ESNEH.

ESNEH is a great place for marketing, and Murray strongly advises travelers to the Second Cataract to stop and lay in a good cargo of live stock for the reminder of the voyage, as higher up the supply of sheep, turkeys, and chicken is extremely limited. One of the chief features of Esneh also is the colony of Ghawazee, or dancing girls, who inhabit a separate hamlet. Esneh is a place of some antiquity, as it

was known to the Greeks and Romans by the name of Latopolis, from the worship of the Latus fish, which, according to Strabo, shared with Minerva the honor of the sanctuary. Above Esneh, the character of the river changes, the sandstone region is soon entered, and the appearance of the hills totally changes. The rocks slope away from the banks, leaving the sides and bases covered with immense bowlders. The strip of habitable country becomes narrowed, and cultivation more arduous and precarious. Grain, however, becomes proportionately more plentiful.



A DAHABEAH.

SAILING up the Nile in a dahabeah has of late years been somewhat superseded by the more prosaic though speedier method of traveling in one of the Khedival steamers. This certainly does away in a great measure with the troubles and trials attendant on a tyrannical dragoman and a discontented crew, to say nothing of unavoidable delays through want of wind; but the dahabeah still remains essentially *the* Nile boat, and its picturesque hull and huge sails always form a prominent feature in Nile scenery. The ordinary tourist dahabeah is fitted up with every European luxury, containing sleeping cabins and a bath room. Those craft intended for native use are far more humble, though by no means less picturesque in appearance. They are fast sailers, and with a fair wind their broad lateen sails carry them along at a fair pace. When the wind drops the boatmen turn out and tow the vessel to a monotonous sleepy chaunt. The smallest tourist dahabeahs have at least two or three cabins and a bath; the largest have from six to eight single-bed cabins, with a saloon cabin in the center and another at the stern, bath, pantry, etc.

TEMPLE AT LUXOR.

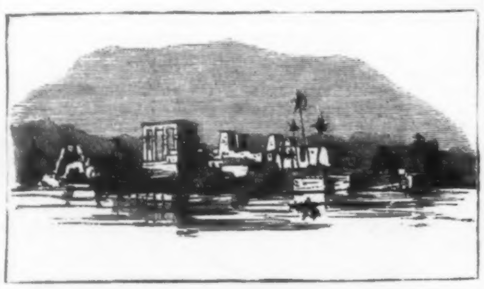
LUXOR, Karnak, and Thebes form but one vast series of ruins, the remains of Luxor and Karnak lying on the eastern bank of the river. Luxor is a splendid approach to Karnak. Its courts, columns, statues, and temples lie in splendid confusion, one obelisk only standing erect, its companion now rising foolishly on the Place de la Concorde, in Paris. Luxor is a market town, deriving its name from words signifying "The Palaces." From Luxor runs an avenue of sphinxes, which connects it with the great Temple of Karnak, to which Luxor is a kind of appendage. The Temple of Karnak fronts the river, as indeed do all the great temples. The Temple of Luxor fronts Karnak. On the quay are the Consulates, and the mud huts of the modern village choke many of the temple buildings; but the fine propylon of the Temple stands near the bank. It was built under the eighteenth dynasty, in the reign of Amanoph III. (1600 B.C.). The lofty colonnade on the river bank was added in the reign of Horus (1480 B.C.).

ASSOUAN.

ASSOUAN is 583 miles from Cairo, and is a town of about 4,000 inhabitants. It is the frontier town of Egypt Proper, as Lower or Southern Nubia extends from the First Cataract to the Second, and Upper Nubia from the Second Cataract to Khartoum. In speaking of these Cataracts it should be remembered that in thus numbering them they are counted from the mouth, and not from the source, of the river. What is called First Cataract from Cairo is, in fact, given as the sixth from Khartoum. At Assouan life and scenery change. The traveler finds himself among the Black Nubians and the inhabitants of the Soudan, while the more craggy rocks that characterize the Upper Nile, and especially the First and Second Cataracts, begin to make their appearance. Up to this point navigation is perfectly easy. Seven or eight steamers go up and down the Nile from Assouan to Cairo (twelve days). Seven postal steamers ply between Assiout and Assouan (four days), and then from Philæ, above the First Cataract, to Wady Halfa (forty-two hours). Nile steamers can pass the First Cataract from August until January, and boats of not more than sixty tons can pass at all seasons. The river bank has always a lively appearance as the large vessels unship their cargo, which is transported on camel-back or by rail six miles up the river beyond the Cataract. For this purpose there is a short railway, and by this our men and stores as they arrive from Siout or Assouan are transshipped and forwarded to Philæ, where steamers will take them to Wady Halfa, a distance of 200 miles.

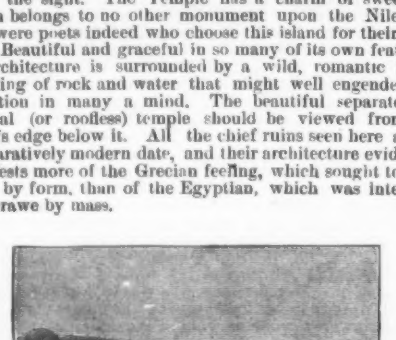
THE HEIGHTS OF ASSOUAN AND ELEPHANTINE ISLAND.

The first cataract, as seen from Assouan, is weird, and not without grandeur. Black rock masses rise abruptly from the foaming current, and here and there blocks fallen from these form islets of 150 to 200 hundred feet in height. The island of Elephantine is opposite Assouan, and is also called the Island of Flowers, from the luxurious vegetation with which the northern portion is clothed. The old town is in ruins, and forms a mere mound, at the foot of which the modern village is situated. Two temples once existed on the island, but the ruins of them were removed in 1822, as the Governor of Assouan wanted stone for building a palace. The south part of the island is still covered with the ruins of old houses and fragments of pottery, on which Greek inscriptions may easily be traced. There are the remains of a Roman quay, and the whole island is a curious medley of dust, ruins, and palm trees.



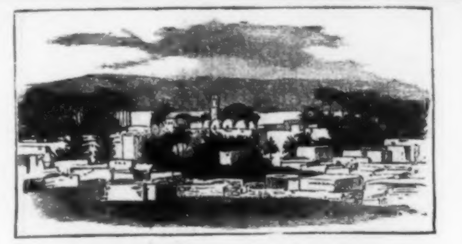
THE TEMPLE OF PHILÆ.

The most exquisite piece of scenery in the whole Nile is that which appears when an elbow in the river is rounded, and the beautiful island of Philæ, with its Temple, bursts upon the sight. The Temple has a charm of sweetness which belongs to no other monument upon the Nile, and they were poets indeed who choose this island for their temple. Beautiful and graceful in so many of its own features, the architecture is surrounded by a wild, romantic intermingling of rock and water that might well engender superstition in many a mind. The beautiful separate hypæthral (or roofless) temple should be viewed from the water's edge below it. All the chief ruins seen here are of comparatively modern date, and their architecture evidently manifests more of the Grecian feeling, which sought to captivate by form, than of the Egyptian, which was intended to overawe by mass.



KOROSKO.

AT Korosko (705 miles from Cairo) the river makes a rapid and beautiful reverse curve, which, through exigencies of space, we are unable to indicate in this panoramic map. From Korosko the direct route strikes across the Nubian Desert to Abou Hamad, the Upper Nile, Shendy, Senaar, and Khartoum. To Abou Hamad is a distance of 227 miles, and a large bend in the river is thus avoided. But the desert is almost waterless, and offers a tremendous obstacle to the movement of a force of any size. It was from Korosko that General Gordon and Colonel Stewart started for their adventurous journey across the desert to Khartoum. Though a place of considerable traffic as the point of departure for the Upper Nile and Khartoum, Korosko is in itself scarcely a village. A few scattered huts lie along the foot of the mountain, and the bank is generally lined with the tents and merchandise of traders.



DER

Is the capital of Lower Nubia, but is little more than a collection of mud huts. It is 692 miles from Cairo. At the edge of the desert at the back of the town is a well-cut temple, of comparatively little interest, of the time of Rameses II. Der boasts only some 300 inhabitants, and on the sandbanks in front of the village crocodiles abound. The name of Der is derived from the "convent" of the old Christian inhabitants. It afterward belonged to the Kashefs of Sultan Selim, whose descendants ruled the country till its reduction by Mehemet Ali. His family still reside there; and the chief people of Der pride themselves on their Turkish origin.

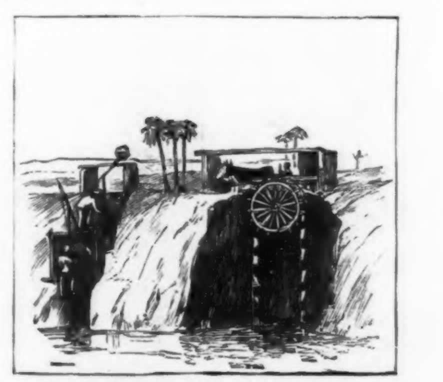
THE SECOND CATARACT.

THE Cataract of Wady Halfa, or the Second Cataract, is from nine to fourteen miles long. Dahabeahs cannot as a rule ascend above the cataract. The boat used above this is the nuggar. Four miles north of Wady Halfa is the north terminus of the proposed Soudan Railway, of which thirty-three miles of rails are laid, the permanent way being completed some twenty-two miles further on. At Sarass the boats of Lord Wolseley's expedition will take the water, and the real difficulties will begin.

In 1871 Mr. Ensor and a party proceeded from Abkeh, at the head of the Second Cataract, in nuggars to Koheh. The journey, about 150 miles, took nearly a month. Between Wady Halfa and Hannek there are caravan routes on both banks of the Nile. Above Hannek the left bank is usually followed. Between Wady Halfa and the island of Say the country is almost an uninhabited desert.

CATARACT OF AMBIGOL.

THIS cataract, some four or five miles long, is impassable at low Nile and difficult even at high Nile. Of the other cataracts that of Semneh is laid down in the Intelligence Department map as impassable at low Nile, and difficult at high Nile, that of Wady Attirah as not difficult, and with a fair wind sailing boats with their cargoes can pass at high Nile. That of Tangour is impassable at low Nile, and difficult at high Nile. That of Omkeh is difficult even at low Nile. That of Akasheh is easy at high Nile and difficult at low Nile.



RAISING WATER ON THE NILE.

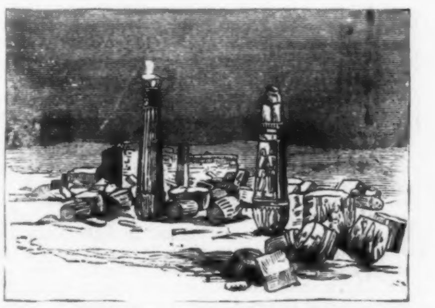
THE Nile is the great fertilizer of Egypt. Without the river there could be no crops, and the land would be little more than desert. Extraordinary pains have, therefore, to be taken with irrigation, and this illustration shows two methods by which the water of the Nile is raised to a higher level, before flowing into the small channels which divide the fields in all directions. One system is that of a lever with a large stone at one end to counterbalance the weight of the bucket; another system is that of a series of buckets on an endless chain. It may here be stated that the current of the river just north of Khartoum averages two knots an hour; between Khartoum and Berber the current at the Cataracts is ten to twelve miles per hour, and between Wady Halfa and Assouan it is three knots an hour.

THIRD CATARACT.

PROCEEDING up the Nile from Wady Halfa, the following minor cataracts are passed: Semneh, Ambegole, Okmeh, Dal, and Kaibar. The last named is seven or eight miles in length. It is impassable at low Nile, but only passable at high Nile. This difficulty surmounted, the next important obstruction is the Third Cataract, or Cataract of Hannek (100 miles from Cairo), which is impassable at low Nile but passable at high Nile. From Wady Halfa to this point the Nile is practically one series of rapids extending over a distance of 130 miles, the passage of three of the cataracts being very difficult. From the Cataract of Hannek onward there is clear water for about 220 miles, and on this stretch of river the rate of advance will depend on the wind and the amount of towing power available.

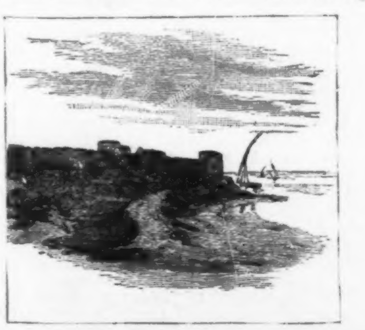
FIFTH CATARACT.

THE Fifth Cataract, or Cataract of El Umas, is impracticable at low Nile. It lies on the stretch of river between Abou Hamad and Berber. There are here no mountains or even hills, and the falls at a little distance are scarcely perceptible. The boats used on this part of the Nile are mainly nuggars. These are manned by three or four men, and have a half deck, which affords some shelter from the sun.



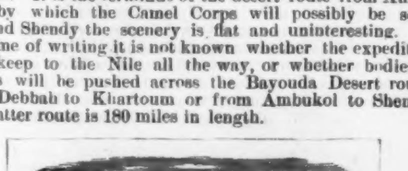
RUINS OF WADY OWATIB.

THESE remains are about twenty miles above Shendy, and near them are the remains of the temple of Abou Naga. Between Shendy and Khartoum is the Sixth Cataract, or Cataract of Shabluka, passable with difficulty by boats and steamers at low Nile. The scenery here is striking, the river forcing its way through a range of hills called Gebel Garri. Another flat and monotonous stretch of country presents itself until the minarets of Khartoum are sighted.



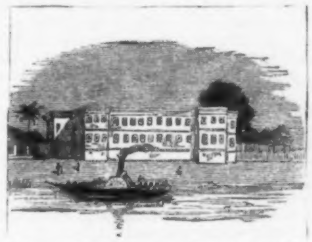
SHENDY

Is the next town of importance after leaving Berber. In 1872 it had a population of 3,000. There is a bazar and market. It is the terminus of the desert route from Ambukol, by which the Camel Corps will possibly be sent. Around Shendy the scenery is flat and uninteresting. At the time of writing it is not known whether the expedition will keep to the Nile all the way, or whether bodies of troops will be pushed across the Bayouda Desert routes from Debbah to Khartoum or from Ambukol to Shendy. The latter route is 180 miles in length.



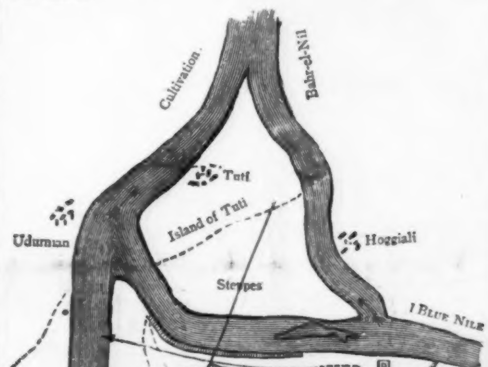
ABOU HAMAD BERBER FROM THE WEST.

BERBER (1,400 miles from Cairo, and 204 miles from Khartoum) is one of the most important towns of the Upper Nile. From it there is a desert route to Suakim of 241 miles, and after General Graham's victories over Osman Digma at El Teb and Tamisi it was repeatedly urged upon the Government that a force of cavalry should be pushed across the desert to occupy the town with the view of opening communications with General Gordon at Khartoum. The Government, however, was of the opinion that such an expedition was either impracticable or inexpedient. At any rate, it was not undertaken. Berber was captured by the Mahdi's forces, when a horrible massacre took place, and most of the garrison and its inhabitants embraced the cause of the False Prophet.



GORDON'S PALACE, KHARTOUM.

THE city stands at the junction of the Blue and White Niles. It name will ever be memorable in English history for its gallant defense by General Gordon. It will be remembered that General Gordon reached Khartoum on February 18, having been dispatched by the Government on a purely "pacific mission," viz., that of evacuating the Soudan, and bringing away in safety the Egyptian garrisons. Gordon at first negotiated with the Mahdi. His offers were rejected, his robes of honor returned. Gordon applied for Turkish troops, for the dispatch of Zebehr Pasha, as Governor of the Soudan, for English troops to "smash the Mahdi." Lord Granville replied that it was not the intention of the Government to send any troops, and refused Zebehr. Then followed Gordon's memorable dispatch, throwing on the Government the "indelible disgrace" of abandoning the garrisons; the Mahdi's hosts advanced; Khartoum was closely invested for four months, bullets falling daily into Gordon's palace from three sides of the town. Some weeks since news was received that Gordon had defeated the Mahdi's forces, and that the siege of Khartoum was raised.



PLAN OF KHARTOUM.

LORD WOLSELEY was already on the way with a relief expedition; and immediately the news of Gordon's success became known, the dimensions of the expedition were curtailed, but preparations were still pushed on with all speed. Some battalions have already reached Dongola. It was from Khartoum that Hicks Pasha started on his fatal march to Obeid, the Mahdi's headquarters, the Egyptian forces being totally destroyed at the battle of Kashgil. At Khartoum, half Nile occurs in the middle of July; high Nile about the beginning of September, lasting about a month, and falling early in October. Half Nile occurs again about the end of October. It is high Nile at Khartoum forty days sooner than at Cairo.

[SCIENCE.]

THE NAVIGATION OF THE NILE.

THE Nile, which during thousands of years has attracted much attention from the intelligent portion of mankind, yet remains in many respects the most interesting of the great rivers of the globe. Its sources, which for so long a time were a mystery, have within the last quarter of a century been rediscovered; but that rediscovery has only rendered it more interesting, and more worthy of study.

The great fluctuations in its flow, and the remarkable, almost mathematical, regularity, year after year, of these fluctuations, can now be practically studied, and their causes clearly understood.

Having its great first reservoir under the equator, we now know that it derives its waters from the region between a few degrees south of that line and latitude about 13° north. It receives its last affluent, the Atbara, south of latitude 13° north, and yet continues its flow, notwithstanding evaporation, receiving nothing, and giving life to the lands it traverses, until it pours the waters of south central Africa into the Mediterranean Sea, in latitude 32° north, carrying in those waters, each year, masses of the *debris* of the mountains of the interior to continually fertilize and extend its delta.

Early in June of each year the flow is the least. The current near Cairo has then a rapidity of only a little more than one mile per hour, and the amount of water passing is only from four hundred to five hundred cubic yards per second. Before the end of June the annual rise commences; and by the end of September the rapidity of the current reaches nearly, if not quite, three and a half miles per hour, the quantity of water passing a given point becoming from *nine thousand* to *ten thousand* cubic yards per second.

Late in October, or early in November, it commences a somewhat rapid decline, which continues until January, when the decline becomes more gradual and regular; this gradual decline continuing until about the end of May, when the minimum flow is again reached, to give place the following month to the new annual rise.

The great regularity of the fluctuations is due to the peculiar sources of supply, and the admirable system of reservoirs and checks which nature has there provided.

The Egyptian Nile is formed by the junction at Khartoum of the Blue Nile and White Nile.

The Blue Nile (*Bahr-el-Asrack*) taking its rise in the center of Abyssinia, and fed by the rains which yearly fall in the mountains of that country during the months of April, May, June, July, and August, furnishes the great masses of water which cause the rapid summer rise, and also furnishes the rich silt, which, torn from the mountains of Abyssinia, spreads over the cultivable lands of Egypt, and yearly renews the fertility of those lands.

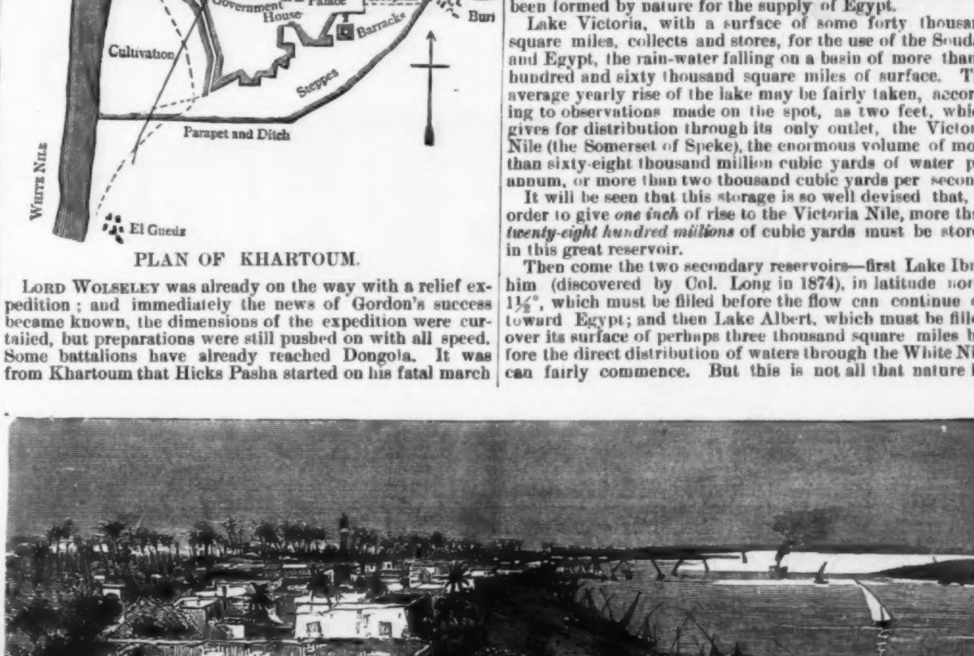
The White Nile (*Bahr-el-Abiad*), flowing from the great reservoir under the equator, guarded in that and the subordinate reservoirs, Lake Ibrahim and Lake Albert, and guarded also by the great system of dams called "the cataracts," furnishes the steady flow of clear water which continues throughout the year.

No human engineer has ever devised, on anything like so grand a scale, so admirable a system for the collection, preservation, and distribution of irrigating waters as has there been formed by nature for the supply of Egypt.

Lake Victoria, with a surface of some forty thousand square miles, collects and stores, for the use of the Soudan and Egypt, the rain-water falling on a basin of more than a hundred and sixty thousand square miles of surface. The average yearly rise of the lake may be fairly taken, according to observations made on the spot, as two feet, which gives for distribution through its only outlet, the Victoria Nile (the Somerset of Speke), the enormous volume of more than sixty-eight thousand million cubic yards of water per annum, or more than two thousand cubic yards per second.

It will be seen that this storage is so well devised that, in order to give *one inch* of rise to the Victoria Nile, more than *twenty-eight hundred millions* of cubic yards must be stored in this great reservoir.

Then come the two secondary reservoirs—first Lake Ibrahim (discovered by Col. Long in 1874), in latitude north 1½°, which must be filled before the flow can continue on toward Egypt; and then Lake Albert, which must be filled over its surface of perhaps three thousand square miles before the direct distribution of waters through the White Nile can fairly commence. But this is not all that nature ha



KHARTOUM.

there done to regularize the great distribution. Between Lakes Ibrahim and Albert there is a great system of natural dams in the cataracts which are found between Foweira and Lake Albert. Then, coming north, down the White Nile, we find, first at Duffli, and soon again at Beddin, successions of rapids, the results of other natural dams; and these we find repeated between Khartoum and Berber, below Abu-Hamed, between that and Dongola, and between Dongola and Wady Halfa. At the last-named place is found what is called the second cataract; and still farther down the course of the river, at Assouan, is the well-known "first cataract." Thence to the sea the course of the great river is unobstructed in its flow, except by the works of man. The great viceroy Mehemet Ali caused, at immense cost, the construction of the famous *barrage du Nil* ("the dam of the Nile") a few miles to the north of Cairo, in the endeavor to make art complete, by a dam, what nature had so well done in Central Africa and Nubia for securing regular irrigating supplies.

The cataracts which play so important a part in the preservation and regulation of the Nile flow are formed by masses of granite rock, which at intervals cross the course of the stream, making enduring dams. It is easy to perceive that, should they be worn away or destroyed, the flow of the river would be made much more rapid during the seasons of high water, and the Nile would become, in Nubia, a fierce torrent during high water, and a nearly dry channel for a considerable portion of the year.

The natural destruction of these great dams by the formation of pot-holes and the friction of *débris* passing over them is, from the nature of the rock, very slow. From such observations as have been made, it is probable that the natural wearing away hardly exceeds six feet in one thousand years, and there is a corresponding effect in the natural rising of the river-bed below the cataracts and in the delta by the deposit of silt from the turbid waters.

The Nile is navigable at all seasons of the year, by steamboats of light draught, from the mouth to Assouan (the first cataract), between the first and second cataracts (Assouan to Wady Halfa), between near Berber and Khartoum, between Khartoum and a point a little to the south of Gondokoro, and between Duffli and Lake Albert. It is only during the season of high water that boats can descend the Nile, passing the cataracts between Berber and Assouan.

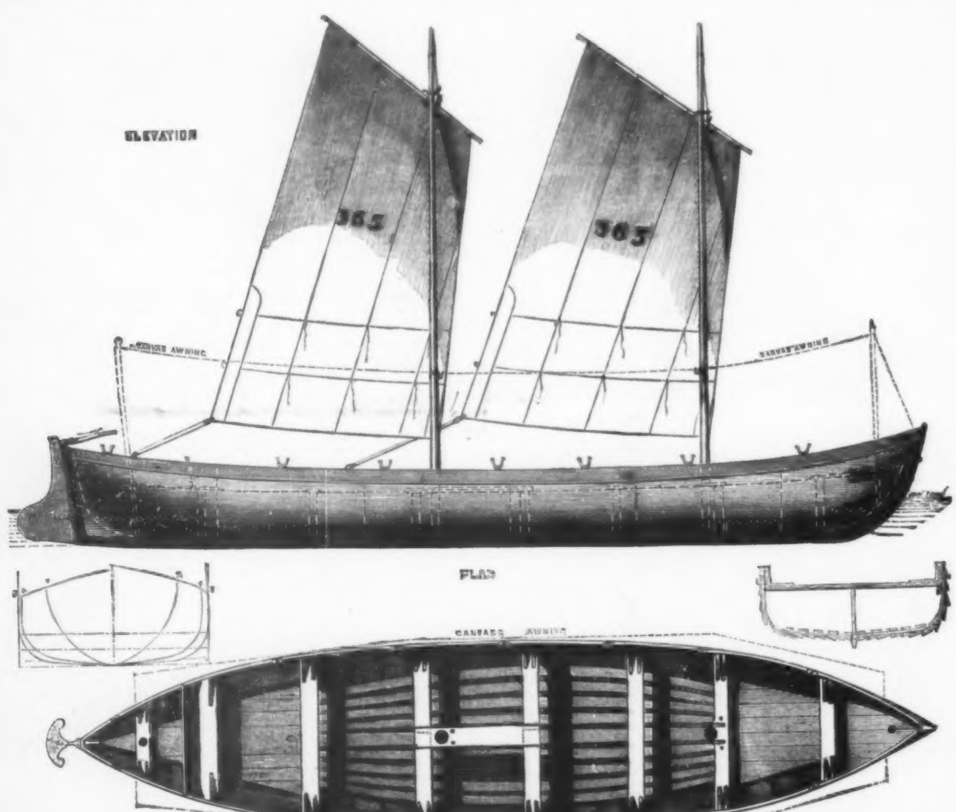
The great danger to boats descending these fierce rapids during high water is found in the eddies near the river-banks, islands, and large rocks. The current is so rapid, and the friction on either hand so great, that the water seems to *heap up* in mid-channel, where the current is the strongest, and great skill on the part of the steersman, and prompt and vigorous work on the part of the engineer of the steamer, or oarsmen of a row-boat, are necessary to keep the boat on the ridge of the current. If the boat is permitted to slide off this ridge, she is quickly caught by the eddies, and almost invariably lost. This is so well understood by the Nubian boatmen that, while they work with a will at the oars in these descents, they always have their personal effects packed in a snug parcel beside them, ready to seize, and they leap overboard, each with his parcel on his head, the moment the boat gets into a hopeless position.

The work of towing or warping boats up against the current is more difficult, but far less dangerous, than the descent.

CHAS. P. STONE.

ENGLISH BOATS FOR THE NILE EXPEDITION.

THE accompanying engraving illustrates one of several boats built for the Nile by Messrs. Cochran and Co., Birkenhead. They have been built to the following specification: Length, 32 ft.; breadth, 6 ft. 9 in.; depth, 2 ft. 9 in. Keel: sided, 2¼ in.; moulded, 3 in. Stem and post sided, 1⅞ in. Floors: sided, 1 in.; moulded, ¾ in.; kilned, nineteen; grown to shape or solid, four. Sided, ⅞; moulded, beam end, ¾; upper end, ⅝; number not less than 60. Gunwales: deep, 1⅝; thick, 1¼; secured to transom with knees. Thwarts: seven, 7 in. wide, with two iron knees at each end. Planks: ⅜ in. thick, not fewer than fourteen each side. Mast thwarts: two, 8½ in. wide at middle, tapered to 7 in. at side. Keel, gunwales, copping to gunwales, rubbing pieces, bilge keels—two each side—floors, futtocks, to be of Canada elm. Garboard strakes, top strakes, keelson, hog piece, risings, rudder, to be of English elm. Planks: Any kind of pine except pitch pine, free of knots, or of English fir. Stern bench, 12 in. wide, secured with knees, two portable seats, backboard; foot-boards, four on each side; bow and stern flats; to be of fir. Stay band, stern band, keel band—½ inch half-round—to be of iron galvanized. Rowlocks: galvanized iron, one at each end of each thwart, one at bow and one at stern, each to have a lanyard. Two boat hooks, six pushing poles, 15 ft. long, tipped with iron. Two grapnels, with six fathoms, 3 in. rope to each. Three hard wood rollers, 4 in. diameter, 4 ft. long, with iron hoops each end. Oars to be of ash wood, 15 ft. long, 12 in number, with copper strip on blade, but without leathers. Awnings to be of light canvas, two wood poles, and with hooks secured to the mast. Rudder to be fitted complete with yoke; a spare rudder, with appendages, to be provided at the rate of one for every ten boats. Rig as per sketch, with light canvas, and with 12 ft. hoist of sail; to be provided with usual tack and sheet hooks, mast clasps, belaying pins, etc.; the masts to be long enough to admit of 2 ft. more hoist of sail. The boats are to be copper fastened throughout, and to have three coats of paint, the third coat to be a light color.



ENGLISH BOATS FOR THE NILE EXPEDITION.

A NEW METHOD OF CONSTRUCTING HORIZONTAL TUBULAR BOILERS.

AT the recent meeting of the American Society of Mechanical Engineers, Mr. Frederick A. Scheffler, of Erie, Pa., read the following paper:

Since the early history of steam-boilers, science, in its progress toward a more efficient and at the same time a more simply constructed boiler, has been constantly nearing the perfection looked and hoped for by the many changes for the better that have been made in the rolling of boiler plates, of either iron or steel. It is true that improvements have been made more rapidly in the manufacture of steel plates for boilers than in iron plates, due chiefly to the fact that the steel plates have no grain to be considered in rolling them either lengthways or crossways for their use in boilers, whereas with iron the peculiarity of its fibrous structure is an objection to the manufacture of large plates.

Were it not for the superiority (as the writer firmly believes) of steel over iron for use in boilers of all sizes, and the fact that plates from the smallest dimensions to the enormous size of sixteen feet long and one hundred inches wide can be obtained, there could be no possibility of a paper at this time on the subject.

When steel can be obtained, for use in boilers, having a guaranteed tensile strength of 60,000 pounds per square inch, an elastic limit of 30,000 pounds, an elongation of 20 per cent. in an 8-inch specimen, and a reduction of area of from 45 to 50 per cent. and which will also bend down close when cold, without fracture, it is very apparent that the superiority of steel over iron cannot be questioned. Another favorable point is, that this quality of steel is homogeneous, and it will not blister.

The fact that these large plates of steel can be obtained caused this question to arise in the mind of the president of the works where the writer is employed: Why not construct boilers of steel in two plates only? The advantages are numerous, and of the best kind.

It is well known that attempts have been made, and these attempts have sometimes been successful, to make a boiler of the style in question with a single plate on the bottom, by hammering and swaging into shape. No reliance can be placed on boilers made by this method, as the iron (when iron is used) loses its toughness and good qualities by being subjected to such a large amount of hammering as must be done to form such a construction. Mr. D. K. Clark refers to some tests that he made on welded iron plates; and although some of the tests were very satisfactory, yet the danger lest it be not known positively whether the weld would be a substantial one or not causes a reluctance in recommending boilers with welded plates. This method is also very costly, and with the uncertainty and cost combined taken into consideration, this method has been abandoned.

By making a boiler entirely of two plates only (except, of course, the flue sheets), the following advantages are apparent:

1. By carrying the longitudinal seams above the water-line (say two inches above the top of the flues) and closing up the brick setting at that height, there will be no seam exposed to the fire other than the lower half of the back head. This is a positive advantage over boilers as commonly constructed, when there are from four to eight seams exposed to the fire.

2. By thus eliminating the exposure of the seams, a greater reduction is apparent of the chances for a leakage around the rivets.

3. The advantage of equal expansion and contraction is so great as also to be of great benefit, and the usual excessive strains are largely reduced.

4. For cleaning the boiler, no question can be raised as to the benefit of a single plate on the bottom. There are no rivets for lodgment of scale, sediment, etc., and there are no seams to interfere with a thorough scraping of the shell.

5. There being no seams vertically, the boiler must be stronger, as there are no holes punched for rivets.

This latter fact is the one that will give rise to the most serious discussions of this paper. It may be questioned whether one large plate extending the whole length of the boiler will be as strong as the same plate cut into two or three pieces and then single-riveted together. Mr. Scheffler holds that the former is the stronger of the two, and that, if the boiler is properly supported, as all boilers should be, there will not be any trouble with the boiler springing or the plates warping.

A set of hollow rolls 16 feet 4 inches long, in the clear, and each roll 14 inches diameter, and 2⅝ inches thick, was designed some time last spring by the former superintendent. When the writer took charge, it was proposed pushing the matter forward as soon as possible, and patterns were made immediately and then put in the hands of the moulders.

The castings were soon under way, and by the first of September the rolls were ready for the first experiment. They were geared to run by belting from the main line running 120 revolutions per minute, and the speed reduced to 3 revolutions per minute, on the rolls. Eight-inch single belting was used. The first sheet experimented with was for a 36-inch by 10-foot boiler, and the plate was 62 inches wide and 10 feet long, by $\frac{5}{16}$ inch thick, of steel. The rolls worked somewhat hard at first, being new, and they were allowed to run two days to stretch the belting as much as possible. The stretch was then taken up and the plate entered into the rolls. This plate went through in good shape, and so did the top plate—the latter rolling up easier than the bottom plate, because the sheet had been punched for the dome and a hole cut for the man-hole. A larger plate was tried next—a plate 12 feet long, $\frac{5}{16}$ inch thick—when it was found that the gearing was insufficient for the work. An alteration was then made, new gears being substituted, by which the power was largely increased, and 10-inch belts were used. The 12-foot plate was then rolled. The amount of power required to roll this immense sheet of steel was entirely beyond expectation. When a 12-foot plate $\frac{5}{16}$ inch thick was attempted, it was rolled entirely by "coaxing," as the belts would slip, although the pulleys were quite large in diameter and as wide as convenience would permit. The pressure exerted on each roll at its circumference, or at the pitch line of the gears on the rolls (the latter being the same diameter as the gears), is estimated to have been 15,000 pounds, and was supposed to have been sufficient to roll a plate of any size that the rolls would take in. The idea of belting was at once abandoned, and an engine was specially constructed to gear directly.

On the 23d of September, 1884, the first 60-inch boiler, 16 feet long, ⅜ inch thick, of steel, was constructed in two plates. This is the *first* boiler of this description ever made in this country, and, as far as the writer has knowledge, in any other country. It is found that a greater degree of accuracy can be maintained in getting the rivet-holes in direct line, and thereby the likelihood is greatly reduced that the boiler-makers will have the chance to use the detestable drift-pin, that greatest of all evils in boiler construction.

Some members may have their objections to the use of steel for boilers, and claim that it is so recent in the market that the method of handling it in manufacturing establishments is not yet sufficiently well developed to be relied upon. The writer heard of a gentleman, a short time ago, who objected to the use of steel for boilers for the above reason. The manufacturers who make a specialty of using this material of course have the advantage over those who use it only on occasional orders; but I do not hesitate to say that, since this material has been in use for upward of eight years, there has been every opportunity that could be desired for all interested to avail themselves of the proper knowledge of the handling of it.

If locomotive boilers constructed of steel should be made with only one course in two plates, from the throat-sheet to the smoke-box, there would undoubtedly be a great reduction of the liability to leakage and wear and tear, and probably a longer life of the boiler would be secured, although the fire-box is generally the first place to need repairs. It is the writer's belief that this new construction of horizontal tubular boilers will be the method of the future for this type, and he hopes that the few points brought forth in this paper will be of service in stimulating discussion and further progress in this direction.

Mr. Scheffler's paper stirred up considerable discussion, which is reported as follows in the *American Engineer*, by Mr. A. R. Wolff, associate editor: Mr. Stirling expressed his satisfaction at any advance in the construction of horizontal tubular boilers, inasmuch as he believed them to be possessed of certain advantages that would insure their use for a long time to come. The main point was, the large water surface, which appealed so strongly to the fireman, since the water-level is the main thing he has to take care of. He considered the lack of amount of water-level one of the principal defects in water-tube boilers. While conceding the objection that the large shell of the tubular boiler did not admit of the highest steam pressures, he maintained that as a fact water-tube boilers are not used largely for power purposes, and not at all on steamships. He desired to ask why the water-tube boilers were not in use on steamers when so much money had been spent to introduce them into that practice?

Both Messrs. Emery and Kent maintained that it was out of place at the time to discuss the relative merits of horizontal and water-tube boilers; but Mr. Stratton pointed out that three of the vessels in the French navy, one of them

for over six years, had had water-tube boilers in successful use. The Voltigeur, one of these steamers, carries 150 pounds of steam. He asserted that any difficulty due to less water surface in tubular boilers was overcome by the use of mechanical separators; the tubular boiler weighed 65 pounds per foot of heating surface, while the water-tube weighed only 40 pounds. In answer to Mr. Stirling's question—how it was that the water-tube boilers had failed in the Guion Line Steamship Montana, notwithstanding that a large sum had been spent in the matter—Mr. Stratton said that the circulation in these special boilers of the Howard type had been bad. Mr. Emery insisted on the necessity of securing high-grade steel for boiler shells, as it was only this that was not injured in the process of making the boiler. He thought this caution specially meet at this time, when so much steel rejected for the United States naval cruisers on account of the high standard demanded for these cruisers was now floating around in the market. Mr. Kent thought it a settled fact that less risk was incurred by the use of steel than by the use of iron for boiler purposes. Mr. Wellman disputed the novelty of Mr. Scheffler's construction, since boilers with one sheet at the bottom had been in use in Cleveland for at least eight years. Mr. Davies believed that a self-contained boiler was the best form. He found that the brickwork cost more than the boilers to set up and keep in repair. In his practice, he had never found the seams to give out, but the sheets annexed to them. A new boiler, only six months in use, that blew up owing to excessive pressure, coming under his observations recently, had the sheets destroyed, but the rivets intact. Mr. Barnes considered riveted seams made an amply good and strong job. A riveted seam can be relied upon as a certain thing, while a welded seam necessarily involves uncertainty. Mr. Davis indorsed the idea of riveting, on account of the possibility by proper inspection of being sure of the job. Professor Denton cited the practice of the Pintsch Lighting Company, which imports tanks of 36 inches diameter welded up (not riveted), which tanks withstand a working pressure of 200 pounds. These tanks, adding import duty, are apparently cheaper than suitable tanks procured in this country.

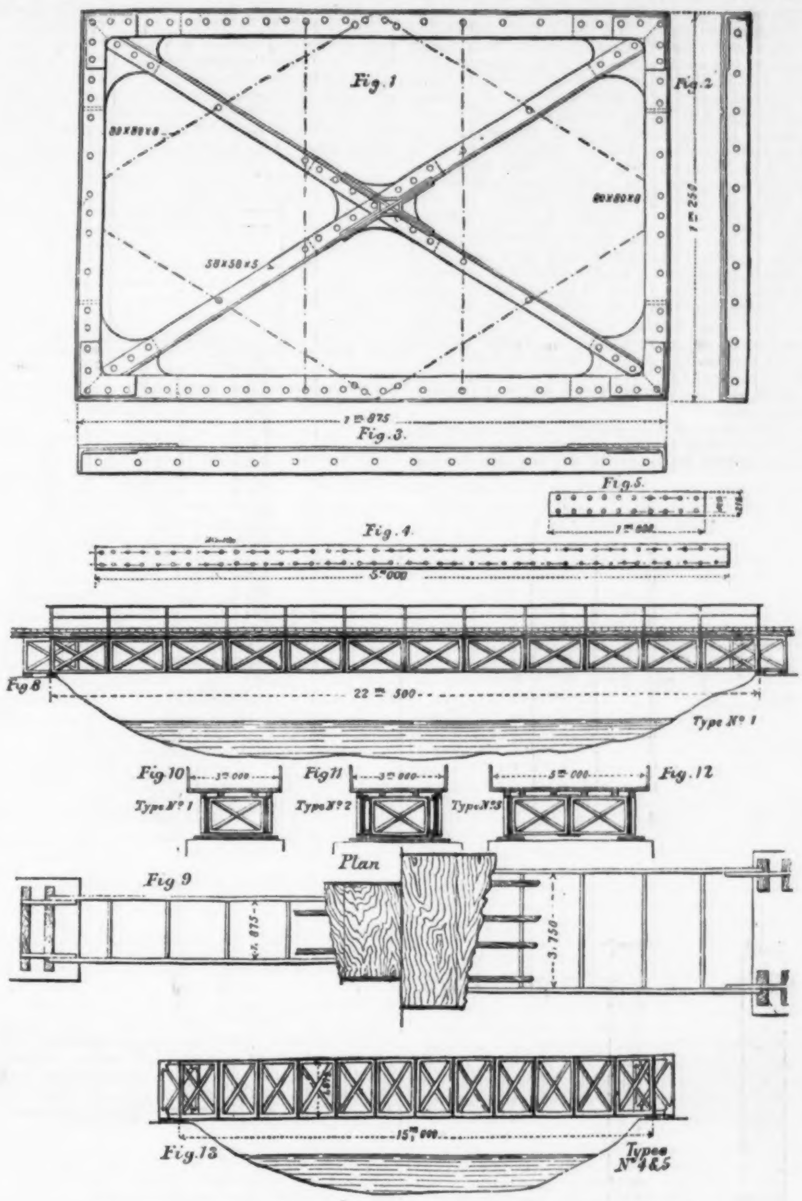
PORTABLE BRIDGES.

AT the Paris Universal Exhibition of 1878, Mr. Alfred Cottrau, of Naples, the well known Italian bridge constructor, exhibited models of a system of portable bridges, which attracted considerable attention, and for which a silver medal was awarded. Since that time Mr. Cottrau has introduced many modifications and improvements in his system, and in its latest development it forms an important collection at the present Turin Exhibition, under the general title of Politetragonal bridges, and made by the Ironwork Construction Company, at their works at Castellamare (Stabia).

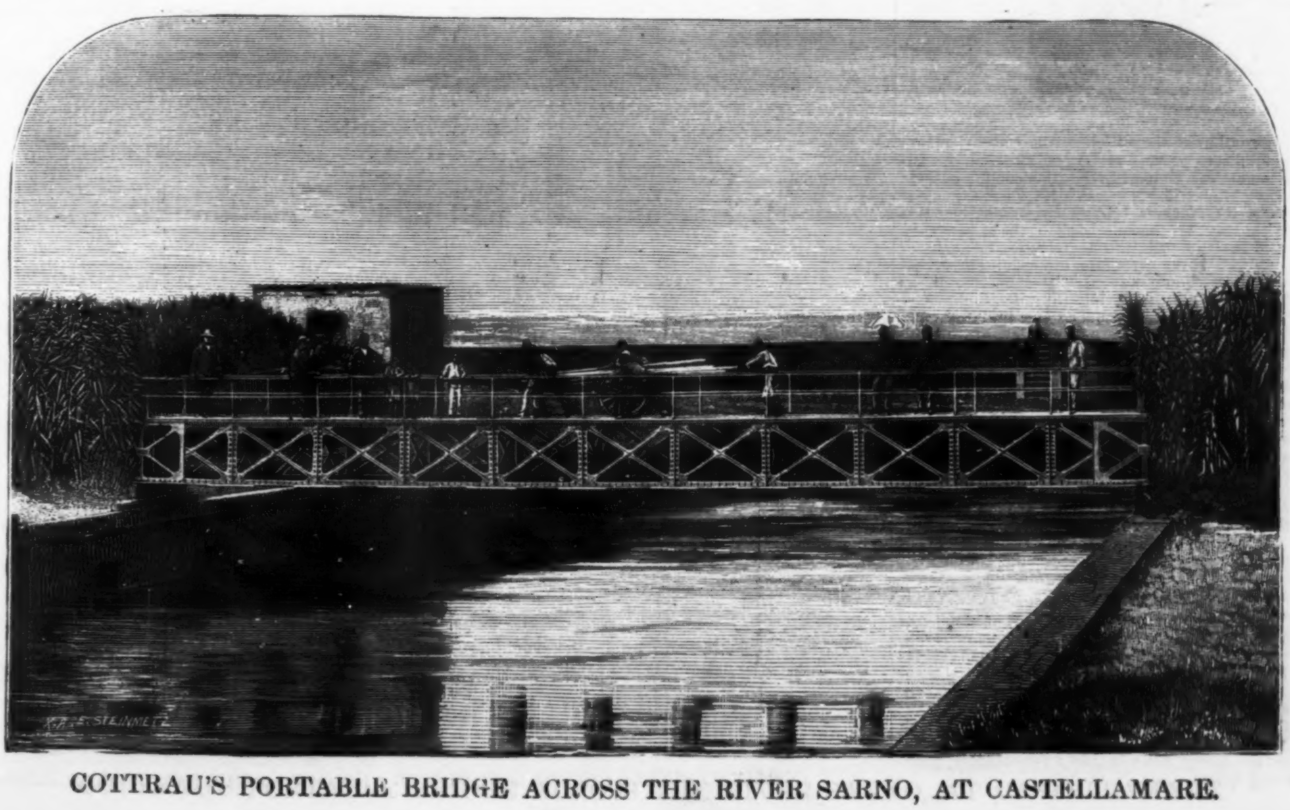
Whatever may be the span (within limits), the width, and the load to be carried, bridges made upon this system are built up of three elements, Figs, 1, 4, and 5, connected by means of bolts or keys, and washers, as in Figs. 6 and 7. As examples of bridges constructed on this system, the elements, Figs. 1, 4, and 5, weigh respectively 220 lb., 103·5 lb., and 22 lb.; all are therefore very easy of transport. The combination and erection of these bridges, even by unskilled labor, or by ordinary troops, is easy and rapid, but with properly trained men a span of 65 feet can be completed within an hour.

It is true there exist other and well known systems of military bridges, the erection of which can be effected in even shorter time, but the special advantage which Mr. Cottrau claims, is that while portable bridges on existing systems are necessarily limited in their spans, his principle is applicable to relatively large openings, the weights of the component parts remaining always the same; moreover, the strength of the structure can be modified according to the load which has to be carried, with much greater ease and economy of transport. The several elements are made of steel, and are calculated for a working strain of about 7 tons per inch, which under necessity may be doubled without danger to the safety of the structure. There is no occasion to enlarge on the various advantages claimed by the inventor for this system. For military and other temporary purposes, portability, rapidity of execution, and strength, which would naturally be tested far closer to the ultimate limit than would be admissible in ordinary and permanent structures, are qualities which speak for themselves. We may, however, devote some space to a notice of some of the typical bridges erected from different combinations of the elements, and which are illustrated by examples at Turin.

Figs. 8 to 12 show an application with girders 4 feet 1¼ in. deep, and adapted for ordinary road traffic, for the passage of soldiers, and for moderately heavy vehicles. In this arrangement, suitable for spans up to 74 feet, the panels are bolted end to end, and form a single intersection trellis. Fig. 13 shows a method of obtaining greater stiffness, by bolting the elements together in the direction of their greatest depth, or two series of panels may be secured side by side, one series being shifted longitudinally through the length of half a panel in such a way as to obtain a double intersection trellis. As is shown in the cross sections, Figs. 10, 11, and 12, the transverse supports are obtained by means of similar elements placed between the longitudinal girders at intervals. Figs. 8, 10, and 11 show



COTTRAU'S SYSTEM OF PORTABLE BRIDGES.

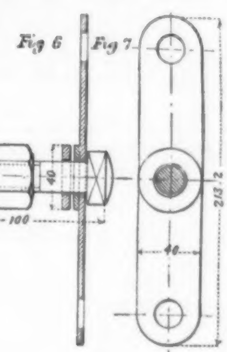


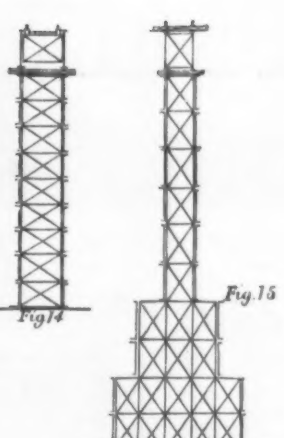
COTTRAU'S PORTABLE BRIDGE ACROSS THE RIVER SARNO, AT CASTELLAMARE.

an arrangement in which the width is about 10 feet, and only one panel is employed. In Fig. 12 two such panels are used, and the width is increased to 16 feet. If desired, three elements may be introduced, and the width increased accordingly. Where additional strength is required, as for the passage of heavy artillery, two light channel bars with top and bottom plates can be introduced instead of one as indicated. From experiments that have been conducted with such bridges as we have described, it has been found that a bridge of 50 feet span, composed of 27 elements, Fig. 1, 36 elements, Fig. 5, and 664 bolts, weighs about 3·4 tons, and will carry safely a uniformly distributed load of 11 tons, or a wagon weighing 4 or 5 tons may be sent over it with safety. A second bridge, 79 feet span, of the same type is also extremely light. Composed of 42 elements, Fig. 1, 12 elements, Fig. 3, 56 elements, Fig. 5, and 1,050 bolts, and weighing about 5·8 tons, its safe working load is 41 lb. per square foot, and it can carry a vehicle of 7 tons.

Bridges up to 82 ft. span, and adapted for heavy military service, secondary roads, etc., can be constructed according to the type Fig. 13, and experiments have been conducted with them, showing that with a total weight of structure of 8 tons, a uniformly distributed load of 17 tons can be safely carried. For larger openings and heavier loads, the elements can be doubled as already explained, so as to make double intersection panels, or the width and number of main girders may be increased. Such a bridge 131 ft. span, weighing 495 lb. per foot run, will carry a load equally distributed of 165 lb. per square foot, with a strain of less than 6 tons per square inch.

A further development of this system, carried out by Mr. Cottrau, is for the construction of railway bridges, either for contractors, for military purposes, or for temporary work;





and by suitably combining the different elements, spans relatively considerable can be very rapidly constructed. Equally the same elements can be used in the construction or piers as shown in Figs. 14 and 15.

In a large majority of cases bridges constructed on this system can be put together on one bank of the stream they are to cross, and be launched into their ultimate position, the extreme lightness of the structure rendering this operation comparatively easy, and without any dangerous strain being thrown upon the steel during the operation. And should it be found advisable to balance the bridge during the period of launching, this can be easily effected by adding a sufficient number of panels of the ordinary elements.

The great amount of care and ingenuity which so eminent a bridge constructor as Mr. Cottrau has bestowed on the elaboration of this system of portable bridges, will doubtless command for it the attention of contractors, military authorities, and others interested in a practical solution of establishing temporary communication rapidly and efficiently, especially in countries where the transport of materials is difficult and costly.

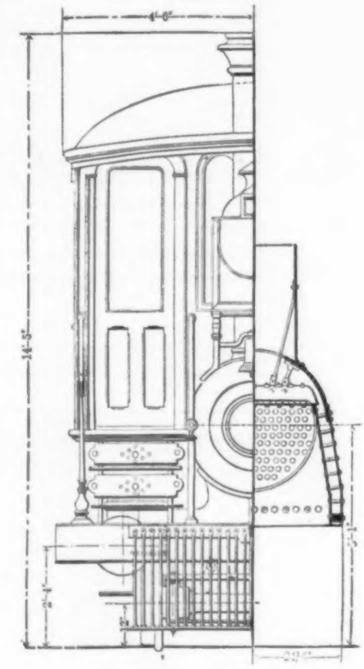
We give a perspective view of a bridge which has been erected on the river Sarno at Castellamare. The span is 22·5 meters (73 ft. 9 in.), and is crossed by two girders containing eleven frames each. Above these there is a light roadway with a railing at each side.—*Engineering.*

Victor Wildman is supervisor of Section B of the road-bed of the Pennsylvania Railroad, New York division, reaching from Trenton to Stelton. A committee of railroad experts has just decided for the third consecutive year that he is entitled to the prize of $100 dollars that the company gives annually to the supervisor of the best kept section of track.

It is said that a glass of water filled to within half an inch of the brim was carried over this section on the window sill of a passenger car, thirty miles in thirty-five minutes, without a drop being spilled.

COMBINED LOCOMOTIVE AND CAR.

This combined engine and car is designed for a service which usually calls for the use of a locomotive as well as a car. In uniting the two a material saving is made in the cost of running, two men taking the place of several. It consists of a single-driver engine, carrying the tender on the frame and having a truck and pilot at each end. The single pair of driving wheels are placed under the shell of the boiler in nearly the same position as the forward drivers of an ordinary eight-wheel engine. The front end, in design and arrangement of cylinders, saddle, truck, and pilot, is not unlike an ordinary light passenger engine. The cab or car extends the whole length of the boiler, inclosing both dome and smoke pipe. Like most single-driver engines, it has shown



Front End Elevation and Boiler Section.

itself capable of remarkable speed, single miles having been made at rates considerably above those of the fastest trains. The absence of a pair of trailing drivers, and the comparatively small size of the boiler, have enabled the designer to get the fire-box into very desirable shape, as will be seen from the cross section through the dome. The water-legs are tapered and spread outward so that the steam leaves the heating surface as soon as it is formed. On each side of the smoke stack there are doors giving access to the car from the platform on the buffer beam, by steps on each side. Just forward of the cylinders there are two other steps placed so that the lower one is about fourteen inches from the ground. The front half of the cab is finished very much like an ordinary car, with the exception of the roof, which is continuous and without a raised deck. At the back end of the dome it is carried up so as to project through the roof, which makes it very high in proportion to its diameter.

One of the peculiar features of the engine is a brake upon the leading truck. The brake itself is a curiosity in its way. It is hung inside the wheels, and is without brake beams. All four of the brake blocks are operated from arms on a rocker shaft which passes through the equalizing bars of the truck. None of the ordinary forms of brake hanging are applicable between the wheels, and an outside brake was out of the question for several reasons. The brake upon the trailing or tender truck is applied in the usual way outside the wheels.

The driving wheels are equalized with the rear truck, although the distance from the center of the driving axle to the center line of the truck is 11 ft. 3½ inches. The means by which this is accomplished is deserving of special attention, as it is equally applicable to any distance. The arrangement consists of two connecting rods, four bell cranks and suitable links, which make the connection with the springs of the drivers and the swing motion of the truck. The load is sustained and distributed in the same way as with an ordinary equalizer carried from the center plate to a yoke resting on the driving springs, while the truck is not only permitted to curve freely, but to have the usual swing motion. Both rods are fitted with turn-buckles, by which their length can be accurately adjusted. The bell cranks in the trucks have the upper or horizontal arm made with a fork, from which a link is dropped far enough to move like the ordinary swing motion link. A transom piece made with eyes passes from side to side of the truck around these links. These eyes are large enough to allow the links to swing without striking. The weight of the engine comes upon the pins holding the bell cranks, the cranks distributing it between the drivers and truck. The front ends of the front pair are connected with the driving springs, while the back ends of the back pair through the swinging links throw the weight on the truck. The relative lengths of the arms of course determine the weight that is thrown on the trucks and the driving wheels respectively. This is virtually the same as changing the fulcrum with an ordinary equalizing bar. The rods are 2 inches in diameter. The transom, or transverse bar, is 1½ inches thick, and the links 20 inches long. The advantage of substituting tensile for transverse strains is a very material one in covering long distances, the construction being both lighter, as well as stronger and cheaper, and enables wheels, or wheels and trucks placed at long distances from each other, to be equalized quite as perfectly and easily as those in close proximity.

The wheels of the trucks are 24 inches in diameter, and the driving wheel 46. The back frame is 3½ inches wide; forward of the driving wheels it is reduced to 3 inches, and is single. The total wheel base is 25 feet 6 inches. The leading truck has a spread of 5 feet, and the trailing truck 3 feet 10 inches. The driving wheels are placed nearly in the center of the engine, being 9 feet 9 inches from the center line of the forward truck. The engine stands 14 feet 3 inches high to the top of the stack, and is 35 feet ½ an inch over all. It is fitted with the Westinghouse air pump and brake, with the reservoir below the barrel of the boiler between the frames forward of the driving wheels.

Engines of this class, though often regarded as luxuries, and frequently discountenanced by boards of directors, are really very convenient and economical, enabling superintendents and managers to go over the road with a speed and convenience quite out of the question with an ordinary directors' car and locomotive.—*Nat. Car-Builder.*

VISCOSITY OF OILS.

By W. P. Mason.

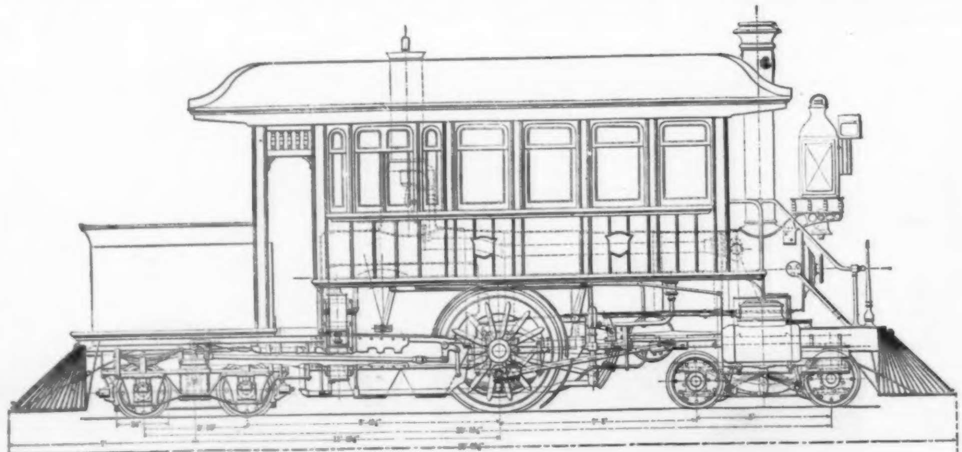
As is well known, lubricating oils are rated by their viscosity, the degree of viscosity being fixed by determining the rapidity of flow through a small orifice, and then comparing the same with the rate of flow of rapeseed oil.

The problem is a simple one, yet very widespread dissatisfaction exists regarding results. Oil has been repeatedly shipped as "full test," returned on account of too low viscosity, and, upon being retested at the shipping point, found to vary widely from the original figures.

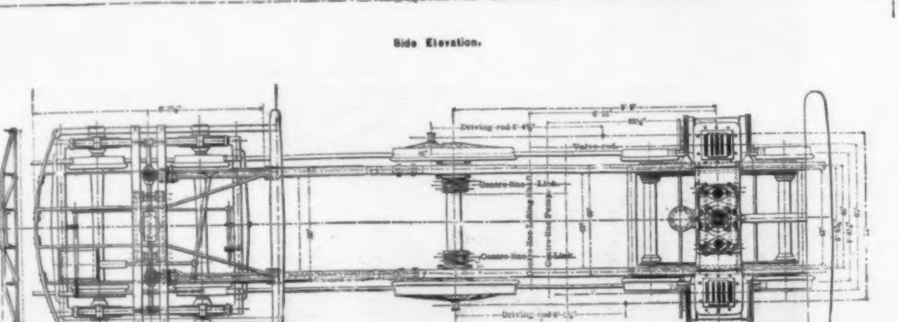
The difficulty lies in the fact that the conditions under which tests are made are seldom twice alike. It is greatly to be doubted if the following questions are often asked:

What were the dimensions of the containing vessel, the nozzle (if one were used), and the orifice?

Of what material were the first two made?



Side Elevation.



COMBINED SINGLE-DRIVER LOCOMOTIVE AND CAR.—LEHIGH VALLEY RAILROAD.

At what temperature was the oil during the experiment?

What was its specific gravity?

What head was used?

Was any change of head allowed for on account of variation in specific gravity?

Overlooking such vital points cannot fail to produce total confusion.

With a view toward obtaining results referred to some definite standard, and therefore comparable, the following viscosimeter is suggested:

A glass cylinder 22 inches long and $1\frac{1}{4}$ inches in diameter, is fitted to a brass bottom $\frac{1}{8}$ inch in thickness. Through the center of the brass plate a hole is bored one thirty-second of an inch in diameter, and from the lower and outside surface the metal is beveled away from the hole a half-inch or more. We have thus practically an orifice in a thin plate. Eighteen inches above the plane of the orifice the cylinder is marked with a heavy line (the standard head), and between the 16 and 21 inch points graduation marks are etched $\frac{1}{8}$ inch apart.

In using this instrument all readings are compared with distilled water at 15·5° C. (60° F.), as being something far more definite than rapeseed oil. The water head is taken at 18 inches, and the quantity of flow limited to 100 c. c. The desired head is maintained by supplying the liquid from a separatory funnel or other vessel provided with a stopcock.

To take the viscosity of an oil: See that the temperature be normal; take the specific gravity and therefrom calculate what the head should be to equal 18 inches of water (it will, of course, be inversely as the specific gravity). Fill to and maintain the calculated head. Determine the time required to fill the 100 c. c. vessel, and divide this time by that required to fill the same vessel with water under standard conditions.

An instrument such as the above has been constructed and used in this laboratory with excellent results.—*Chem. News*

THE WALL.*

By Prof. T. ROGER SMITH.

A WALL, you may perhaps feel, is too familiar a subject to be a good theme for explanation or illustration, too commonplace to be worth study, and too simple to need it; in short, especially to those who are beginning their career as architectural students, the wall may seem a poor subject. But whatever I may fail to accomplish to-night, I hope at least to convince you that this is a rich topic, full of matter; and I am not without the hope that I may succeed in making you feel that it is full of interest also. In order to give a hint of how much such a subject might cover, I named the gable and the tower in giving the title of this lecture; but we have a good deal to talk about before we rise as high as either the one or the other of these lofty features. Of the essentials of a building, the wall is, I take it, the second. It comes midway between the floor and the roof; and though one cannot absolutely say that there are no buildings without walls, we can find extremely few such.

The first thing to consider in approaching this subject is the physical qualities and mode of constructing the wall, its materials, the cement that binds them together, the base it stands on—all of them matters affecting the wall as a specimen of the builder's art. We shall then be better prepared for considering the wall as a feature of the architecture of buildings, taking the word architecture in its artistic meaning. First, then, about building walls. The preparation for building a wall is, as every one knows, to find or make a foundation. A bad foundation is literally, as well as in a figure of speech, at the bottom of most of the failures that occur in walls. When a good foundation is secured, the success of the wall is rendered possible. What is a good foundation? The best is one that is perfectly immovable and incompressible, such as rock. The house built upon a rock is the one safe to stand. Next to this, and only one degree less good, is the foundation which may yield or compress slightly under a load, but will do so with perfect uniformity. Soft, irregular, shifting foundations, and those exposed to the action of water, frost, and air, are among the most notoriously bad ones.

The ordinary London foundation is clay, in some cases mixed with loam or sand. In building on it great care is necessary; the foundation must be carried so low below the surface that frost will not penetrate to it. To secure this in the London climate you should go 4 ft. deep, and even more. The surface round the building should also be protected so as to prevent the percolation of water. The weights of the different parts of the wall should be as nearly uniform as possible, and they should not be extreme. Four tons per foot superficial is quite enough. It has become a practice of late years to form a kind of artificial rock of concrete upon the foundations of earth or clay, composed of small stones and lime or cement. This concrete, which hardens into an incompressible slab, admirably spreads and distributes the weight, and is of great use in preventing disaster. In the case of very bad foundations enormous quantities of concrete are often employed, and with success. The base of the wall, like the concrete, is below the level of the ground. It is, to some extent, a modern improvement, or at least it hangs on to the modern notion of building thin walls.

In the Middle Ages, when walls were immensely thick, it was not very often customary to build them with spreading footings; now it is usual, and a most useful custom it is. Walls in London are required by law to be twice as wide at the bottom of the footings as they are themselves. Where concrete is used this is wider still, and so it happens that a wall of say 18 in. thick rests on from 4 ft. to 5 ft. in width of the material of the foundation, and thus a weight of, say, twelve tons per foot-pound of wall would only press on the actual foundation with a stress of about four tons. The base of a wall usually shows itself above ground in the form of a base moulding or plinth, a feature used, and with great effect, to satisfy the eye, and to which we shall return in the second half of the lecture. In some few cases, as for example in some of the French and Edwardian castles, the wall of towers widens rapidly toward the base with excellent effect. We now come to the wall itself, and it may be convenient to ask for a moment what services it is usually expected to render. They may be perhaps described as threefold—inclosure, shelter, support.

The inclosing wall, if it do nothing but inclose, like the wall of a churchyard or garden, has not much to do, and seldom needs to be specially good; but the inclosing walls of town or castle which were once (and are even now) wanted for defense, had and have to withstand all kinds of deadly weapons. Of old it was battering-rams and engines to cast stones, now it is rifled ordnance and deadly shells, and enormous strength, solidity, and piers are required. When your wall has to shelter the inmates of a building, as well as to inclose the space, it has a more complicated duty to perform. Its thickness may be and often is much reduced; but attention has now to be paid to the materials of which it is made, especially its face, so that it may be not only stable, but weather-proof. In this climate weather-proof means keeping out rain. In some others it means keeping out heat, in others keeping out cold. Support means ordinarily the carrying intermediate floors (if any) and a roof; and it often happens, if the roof be of special construction, that the shape or strength of the walls has to be modified to correspond to it.

For example, the vaulting of any Gothic church renders necessary the construction of buttresses at the points where lateral strength is needed, or the wall would be in danger of being thrown over by the thrust of the vault. There is another service which a wall may be called on to render, namely, separation; and in actual practice a great deal has to be done by those who build in London with respect to party-walls separating one tenement from another; but I will spare you any further reference now to so very technical a subject. Of all the properties a wall can possess, I think stability is the most noteworthy. Of old this was sought in great thickness. The Romans first showed that constructive skill would enable men to build walls thinner than had been customary, and yet stable. Our modern walls are vastly thinner than those of the Romans; but then there are few modern buildings for which we expect, or could desire, a durability like that of ancient Roman work. Good materials, good putting together, and strong cement, with some amount of protection from weather, are what we must rely upon for the preservation of our walls.

Homogeneousness, or the use of materials all of one sort, would seem at first sight to be essential to the construction of a good wall, and yet though many ancient walls, like those of Munich, and, I believe, those of Athens, were practically homogeneous, the walls cleverly put together by the Romans of three or four different sorts of materials have proved some of them to be all but indestructible. "What do you mix your colors with?" was once asked of the greatest landscape painter of the century. "With brains," was the caustic reply, and the old Romans managed to show that brains were also good to mix mortar with. *Uprightness* is essential to stability, and to look safe a wall must be obviously upright, though a tapering form, like the *pylon* of an Egyptian temple, also looks strong, and really is so. *Length* was the ancient way of giving importance and dignity to walls; height is the comparatively modern way. In the early ages of the world, and in the ruder stages of the development of modern nations, it is *extent* that is relied upon where an effect is to be produced.

The greatest of the temples of Egypt, for example, the temple of Rameses, with its dependencies, extended over about 2,000 ft., or more than the third of a mile. The rude stone avenues of prehistoric origin met with in Brittany extend over a mile and a third of country, and, as another example of a different kind, I may recall to you the Roman wall which stretched right across the north of England. As the power of building and skill in the production of architectural effect increased in any nation, height was more sought after than extent; but it was, with a few exceptions, reserved for Christian and modern architecture to attempt with success buildings in which height is the main feature. Straight lines and right angles seem to have been almost the only rule in very ancient work, such as the Egyptian and the Assyrian. The Greeks first introduced curved walls in their theaters. The Romans continued and extended their use, and introduced polygonal shapes, all of which have obtained ever since.

Colored materials are to be met with at all periods of the world's history; but as their use always has reference to the architectural effect of the wall, we will postpone them to the second part of the lecture. Having now looked a little *at* our wall, let us try to look *into* it as far as we can, and perhaps an architect can look further into a stone wall than some other people, notwithstanding the old proverb. What then are walls made of? You may lay it down as a general rule that a wall must be made of something that lies ready to hand. In many cases the fact that the material of which some small or ornate object is to be made comes from far is a point in its favor. We prefer Italian marble to Derbyshire, or to the serpentine of Cornwall, not because they are always more beautiful (for they are not), but because they are Italian. But for wall building so much and such heavy stuff is wanted that it never does to bring it far. Accordingly, in localities where nothing else is to be had walls are built of earth. In Devonshire, for example, cottages, barns, and the walls of gardens and orchards are commonly of earth, and they are warm, solid, and, if well taken care of, durable; but moisture must not be allowed to get into the heart of them, or they will soon crumble. Next to earth is a material not, so far as I am aware, known in England, but once in use in the East—sun-dried bricks. Vitruvius says that the walls of Babylon were built with sun-dried bricks laid in bitumen; and it is supposed that they were largely used in Assyria and Babylonia, and that some of the shapeless mounds which now mark the site of ancient structures consist of a mass of what was once sun dried bricks. Next, of course, we should come to brick—the material only too familiar to the London eye, and the refuge of builders throughout the world and of every age who, like the London builder, were not so fortunate as to have stone within reach.

In Egypt and many parts of Italy there are remains of brickwork of great antiquity, and in Lombardy, North Germany, France, Belgium, and our own country brick has been extensively used, and is in use at the present day. I should occupy the entire evening if I told you, as I hope to tell the students of the constructive courses, only very hastily how bricks are made and burnt, what are good and what are bad, and how they are to be laid in a wall. I can, I think, only remark that bricks are not always of the sizes and shapes we are familiar with. The Romans made them flat, more like our tiles, and in many European countries they have been used considerably smaller. The size is a good deal influenced by the weight. An English brick can be held and managed by an artisan with one hand. If it were much larger or much heavier it would take two hands, or even two men, as were probably employed on the Roman bricks.

The most refined kind of brick is called terracotta. It is of the nature of brick, but bears the same kind of relation to it that marble does to stone, or silver to pewter. Terracotta is, in theory at any rate, the most appropriate ornamental substance to employ with brickwork, and though there are some practical difficulties in the way of using it, when these are overcome it is an admirable material. The best and most desirable material for wall building is, however, stone. Every sort of stone that is in the least degree deserving the name of stone has been made use of for the purpose of wall building, from flints, which are some of them as inconvenient in shape for the mason's use as potatoes would be, up to the hardest granite, the finest and truest freestone from our many excellent limestone and sandstone quarries, or the beautiful and precious marbles of Greece and Italy.

There are stone walls in Greece and in the Etruscan plain, which have come down to us from remote antiquity, made of large polygonal stones unwrought—or but slightly wrought—and coarsely fitted together without mortar. There are others in Egypt of the finest polished granite, with joints so close and true that the edge of a sheet of paper cannot be got between the blocks; but as remarkable in its way as these specimens of consummate handicraft is the construction of the Roman walls, which were often made of small stones, such as we make macadamized roads of, set in a tenacious mortar which has hardened till it is as strong as the stone itself, and steadied at intervals by the introduction of a bond-course of flat bricks or large stones. With this mode of construction, which could be carried out anywhere, the Romans built vast works, the ruins of which remain all over Europe.

There is quite as much to learn about stone as about brick; in fact a great deal more, as, for example, how to select stone, for, owing to the ease with which many sorts of stone are acted upon by the weather, there are many precautions to be taken in the selection or use of material. I will just name the three cardinal ones, which are these: First, select for use stone from a quarry, and from a bed in that quarry which experience has shown to be durable. Secondly, let that stone lie in the building in the same way as it lay in the quarry, or, as masons would say, bedwise. As an illustration of this you may make an imitation of a wall of books laid flat, and they will do very well; pile the same books on their edges, and they will illustrate in a few minutes what will be, in the course of time, the behavior of blocks of stone that are face-bedded, that is to say, laid the wrong way. Thirdly and lastly, take such precautions as will insure that no moisture gets into the inside of your wall, or into the heart of the stones that compose it. The materials I have named all of them require to be held together by some sort of cement if the wall is to be durable and weather tight. Lime is at the bottom of all the cements in general use, and its faculty of hardening after being calcined and slaked, and as it hardens of adhering to the surface of the stones or bricks with which it is in contact, is invaluable. Mortar is made of quicklime and sand. Cements and hydraulic limes are compounds (natural or artificial) of lime and other substances, chiefly alumina, which enables it to set harder, and under water, and more rapidly than in its unmixed state. Plaster of Paris, so serviceable to the French builder, is sulphate of lime, and so on through all the series of cementing agents.

In putting walls together great skill is often shown in the bonding or interlacing of the bricks or stones, by means of which they are enabled to hold one another tight; and when big stones are employed, or much difficult masonry occurs, it is generally speaking essential for the materials to be cramped and tied together by cramps, dowels, joggles, bond-courses, and ties. Before leaving the subject of walls built of bricks or stones and mortar, I ought to say something further as to the fact that from the time of the Romans to our own day very few walls have been homogeneous, that is to say, built of the same materials throughout. This sort of rough masonry of small stones, which I referred to just now as much used by the Romans, was not very well adapted to stand the weather and to look handsome; accordingly it was a frequent custom to coat it with a surface of finer stone in larger blocks, as well as to bond it by courses of stones or brick; and this sort of construction has been, with more or less skill, in use ever since.

I need hardly point out that where the heart of a wall is of many rough stones laid with much mortar (a substance more or less compressible), while the face is formed of few well-dressed and squared stones laid with little mortar, there must be great risk of the two parts of the wall behaving differently the one from the other when weight comes upon it. This happened in much of the work of the builders during the 11th and 12th centuries in England—the period of the Norman style. Professor Willis has gone so far as to say that if a Norman tower has not fallen, that circumstance throws great doubts upon its being Norman. Certainly an immense number of them have fallen, and as an example of failure, happily anticipated before there was a fall, I may remind you of Peterborough, where the core of the Norman piers carrying the great central tower has crumbled, and the piers have arched, and have been taken down within the past year.

Different from the practice of building composite walls is another which I will only just mention, that of building hollow walls as a protection against damp. We have by no means exhausted the list of materials for walls if only your patience will hold out. A modern material which I will just name, but not dwell on, is concrete, excellent if well looked after, dangerous otherwise; cheap if used in large quantities and where there are few features or irregularities, but far from cheap in small or intricate buildings; very strong, very durable, and sometimes valuable where nature yields few materials for walls of another sort. Timber has been used time out of mind for the walls of houses, and even churches and dignified buildings, in the spots where it is plentiful. There is evidence that timber buildings were in use in Assyria, Egypt, and Lycia, from the curious fact that ancient remains of stone or marble are actually cut into shapes that imitate timber; indeed, the whole system of architectural treatment in use in Greece is a kind of petrifaction of timber construction. The countries of Europe where timber buildings are now mostly to be met with are Sweden, Norway, Russia, and Switzerland. They are in many ways excellent. A timber wall is by no means a bad protection against weather; but it is liable to catch fire, and so quite unfit for use in cities. Many railway stations in England, however, are built of timber, and any one of these will serve to illustrate a cheap way of building timber walls. In Sweden whole logs, halved at the angles, are used, and a wall far more solid, durable, and weather-tight can be obtained. The same method is followed in Russia—and you may see a good specimen at the Health Exhibition in the Russian house at the back of the dairies. Timber framing filled in with plastering or with brickwork in the spaces, called usually half-timbered work, is an excellent material for walls if done with the solidity and liberal use of strong timbers that was common in England in the sixteenth and seventeenth centuries. In Lancashire and Cheshire, in Worcestershire and Gloucester, in Kent and Surrey, and in

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other parts of England you may find many fair half timbered walls, and even here and there one still lingers in London or the outskirts. We have in these later days taken to build our walls of glass, as at Sydenham, and of corrugated iron, as in many temporary rooms and churches, and each has its uses. The newest material for wall construction in England (though not, I believe, new in China and Japan) is paper. At the Health Exhibition a very serviceable little cottage walled and roofed with paper may be found. It is known as the Willesden Cottage, and I think I may say from some little experience of it that its walls are by no means the worst within which I have been sheltered in my lifetime. We will now leave the construction of walls, and turn to their treatment as an important factor in architecture. A wall, as we look at it, ought to have three parts: its base, which though below ground ought to be represented by some description of plinth or base moulding, its body, and its top, which may be a coping to throw off water, or may be the overhanging eaves of the roof which it carries. These, then, are infinitely varied, but they are generally all to be seen in any wall that is architecturally satisfactory to the eye. The different ways of dealing with a wall as an architectural feature may perhaps be grouped as follows:

I. Emphasizing construction.
II. Making construction.
III. Varying the outline or plan of the wall.
IV. Enriching the surface of the wall.
V. Color.

These, of course, interlace and interchange, and I adopt a classification not because the things classified are really quite separate, but because it helps us to consider the different sides of the same subject one after another, and to be sure we do not omit something vitally important. Of the methods of emphasizing construction, which is our first division, a very ancient and obvious one is to use large stones. This was a favorite plan with the Egyptians and the Greeks, especially in archaic times. Great stones were used in the Pelasgic walls, large remains of which still exist in Greece and in the Etruscan plain in Italy. These stones were usually polygonal, very carefully fitted together, built up without mortar; such form strong walls, and they impress the spectator very much by the appearance of savage strength which they present. Stones of very large size occur in Greece and in Egypt, and in Syria stones remarkable for their dimensions and for the way in which their outline is marked round with a broad, round mark. Capt. Conder, who has measured many of them, has been kind enough to give me some particulars. He says:

"The stones in the Temple wall at Jerusalem are generally 3 ft. 4 in. high, with a draught 3 in. wide, and ½ in. deep. The longest stone is 38 ft. 9 in., and there are many 20 ft. long. The 'master course' is 5 ft. high.

"The stones in the Hebron Haram are exactly like those at Jerusalem in all respects, including the tooling with a toothing adz driven by a hammer, and bosses and lewis holes for moving the blocks.

"There are four stones of great size at Baalbek—three in the wall and one in the quarry. The latter is the largest. It is 68 ft. long. Those in the wall are about 63 ft. long and 14 ft. high and thick. There is a large amount of masonry at Baalbek about the size of the Jerusalem masonry, and draughted and finished like it. These stones bear Greek letters, apparently masons' marks, and are of the 2d century A. D. I think myself the larger stones are probably of the same date.

"There is another building with great stones in Syria not to be forgotten (see "Heth and Moab," pp. 164-170). It is the palace of Hyrcanus, built about 176 B. C. The stones are 7 to 10 ft. high, and 20 to 25 ft. long, larger than the Jerusalem stones; but they are only 2 ft. 3 in. thick, which is peculiar, as there was no backing.

"It seems then that the Jews used this masonry in the times when they became acquainted with Greek architecture; and I believe draughted masonry is found at Athens in the Acropolis, also of great size, but I know no details. The temples at Thebes have stones quite as large as those in Syria, I understand.

"I do not know a single fact to lead us to suppose that the Phœnicians used this kind of draughted masonry, or that Solomon would have used it. I do not think the Jerusalem masonry is older than Herod's time."

Another mode of emphasizing construction, which the Jews seem to have taken a pride in, is the employment of large corner stones. When a wall is built of small or loose materials, it is not easy to make the corner strong; in fact, in parts of England the towers, which would otherwise be square, are round, because there is little else but flint to build with, and with flints you cannot make a square corner. It is usual, on account of this tendency to weakness, to fortify the corner by building it of larger stones or better than others; and the Jews seem to have attached some semi-superstitious importance to the top stone at the corner of a building—perhaps a more really appropriate place for a famous stone than our "foundation" stone, which rarely, if ever, is part of the foundation. These stones at the corners came up again in Roman work, and still more frequently in the styles derived from Roman. The famous long and short stones at the corners of Saxon buildings, the well-marked quoins of Gothic ones of all ages, and the carefully wrought, rusticated, and raised quoins of Renaissance buildings, all go upon the principle of marking construction. In simple and homely structures, built of materials with a fine surface or good color, any method of marking the structure of a wall is successful. In Cumberland and Westmoreland, where many varieties of stone rich in color are met with, the walls of humble churches, or even cottages, are sometimes quite a sight to see and admire from their beautiful and varied tints, especially if a method of walling be adopted which allows the natural cleavage of the stone to be seen without any tooling. Another and an opposite mode of emphasizing treatment, if not construction, consists in exaggerating the squaring and dressing given to stone, and bringing it to a surface of the utmost smoothness. In the later part of the Gothic period, and in much of the Renaissance architecture which followed it, the whole surface is rubbed, and no trace of the tool is left. The same completeness of workmanship was also to be met with in Greece and in Egypt, and wherever we encounter it the spectator seems to be made sensible of the immense pains and care that have been lavished by the builders upon their wall; and to a less extent the same effect is produced by the selection of materials with a fine texture of surface and a good color, like choice bricks. A wall consists of stones and joints, and one way of marking the construction is to make the joints more conspicuous than they naturally would be. We have seen that in ancient Jewish masonry a *draught* or breadth of finely tooled work surrounds the margin of the stone. In some Greek work we meet with a severe square sinking at the joint, and in Roman work with a more strongly marked channel. In the revived Roman, which we know as Renaissance, this accentuation of the joints of stone is practiced often with great frequency; and the refined mason's work, to which we have given the absurdly inappropriate name of rustication, is one of the sources of the great beauty of many of the Italian palaces and houses.

There are many other ways of emphasizing construction to which I have not time specifically to allude, but may say generally that any treatment of a wall which makes its materials or its construction evident almost invariably adds a natural and, so to speak, a spontaneous grace to buildings. This is nowhere more perceptible than in the half-timbered houses of our own country, and the entirely timber walls of houses in Switzerland or Sweden. We will now pass to our second group of methods of architectural wall treatment—methods which mask or conceal the construction. The inner face of a wall is almost invariably shrouded in some kind of covering; but even the outer face is as often as not of a nature to conceal the structure. I have already spoken of the custom of *facing* walls, and have pointed out that it may, and often does, render them more fit to resist weather. But for one case in which it is done with this legitimate object you will find scores when it is done for the sake of appearance, and this at every period of the world. There is not one wall in fifty that is built through its entire mass of the same material as on its outside —nay, I have known walls built of homely but durable materials faced with something better looking but not so thrustworthy, like a wall of good sound London stocks faced with soft porous red or white Suffolk bricks. I am not going to denounce this as a sham —it used to be very much more the custom to talk about absolute truth in architecture than it now is, and I do not think there is any real sin against good taste in using two materials in one wall, the one fit for the heat and the other fit for the face, if it can be so done as to make a solid structure. Where stone is very scarce, as in London, is very costly, as is the case with the marble used for the outer face of some Italian churches, it has been the custom, and, I suppose, always will be, to use it for the face only. Of course, where this done it is not infrequently the case that the thin facing is so used as to give the idea of enormous massive blocks, a deceit which I do not advocate or recommend. Another mode of covering the construction up is to case a wall with some description of plaster. This is often structurally of great advantage in keeping out moisture, and if so done as not to imitate stone is no doubt quite legitimate. Many English country churches were built to be plastered, and have been covered with plaster from their origin till the present day, and now find themselves exposed naked to the weather, stripped of their proper garment, all the seams and joints of their originally rough masonry brought to view, their quoins sticking up three-quarters of an inch from the general surface, and their appearance not what the original builders intended.

Among methods of construction I may just name a curious one, common until lately in Sussex, of building walls of timber framing and then hanging tiles on to them, so shaped and fitted together as to look like brickwork. Many of the apparently brick walls in Hastings, for example, are really only woodwork tiled. When we pass from the outer to the inner face of our wall, the consensus of all civilized nations in all time tells us that it is legitimate to take the wall surface as a basis which we may adorn, enrich, decorate, and hide away as we please; and the methods which have been employed are very various. First, both from its antiquity and its universality, is the use of plaster. The inner face of Egyptian tombs, temples, and palaces was constantly plastered; on this pictures were incised, something like sculptures in very low relief, and the whole was then painted. Traces of plaster and color on it are found in Greek work, and abundant remains of it in Roman, and it has been in constant use ever since. Its capacity for receiving ornament in relief and for taking color has made it at times the vehicle of decorations which have a world-wide celebrity. The arabesques of Pompeii, the Loggia by Raphael in the Vatican, the whole series of grand frescoes in the same palace, not to speak of those to be met in almost every one of the churches and palaces of Italy, and the embossed decorations of the Alhambra, are among the most prominent examples of the artistic treatment of plastered walls. A still finer wall-covering is the use of mosaic. Nothing can be more impressive than the mosaic pictures which line the walls of early Christian churches both in the western and the eastern district, and in the last named part of Christendom the use of mosaic has never been abandoned. It is also retained in the finest Renaissance churches. Marbles and other fine stones capable of being sculptured were never so profusely used for wall-lining as by the ancient Assyrians, and the slabs from their palaces which are to be seen in the British Museum may give some idea of the nobility of this wall decoration. The great extent to which it was employed may be judged from the palace at Koyunjik, where Mr. Layard estimated that two miles of wall face were riveted with sculptured slabs of alabaster. Lining walls with marble, in slabs or panels or inlays, has been often practiced since. Perhaps the finest comparatively modern example of this method is St. Mark's at Venice, where it is combined with mosaics.

The use of wooden wainscoting, paneling, or ormolu finishing has also been very general wherever wood was easily obtained; but, of course, no specimens of the use of so comparatively perishable a material have survived from at all remote times. In the combination of two or three of these methods the architect enjoys the means of producing the richest and most varied effects, especially in domestic and secular buildings, where there is often room for a great flow of fancy and a rich display of taste and skill. The third division of this part of the subject is varying the outline or plane of the wall. In Egyptian, and, as far as we know, in the West Asiatic buildings, the top of the wall was level; the roof in these countries being usually flat, and being desired as a terrace quite as much as a protection from weather. In the more temperate climate of Greece we meet with the sloping roof, and consequently the gable. Here we have one of the simplest yet most successful treatments of the wall which architecture possesses. The noble pediments full of sculpture, which formed the great features of Greek temples; the less splendidly sculptured but still dignified pediments of Roman porticoes; the broad arcaded west fronts of Christian churches, of round-arched architecture, and the steeper gables of Gothic ones, sometimes filled with the vast circular window which so often enriches the facade of a great cathedral—each of these shows in its way the value of the gable as an architectural feature. The gable is not, however, confined to temples and cathedrals; it is equally characteristic and useful in the simplest domestic work and in the noblest secular. Perhaps no finer example of its modern application exists in London than the pediment of this college, with its finely designed flights of steps. Of the value of this feature in picturesque architecture the half timbered cottages in Kent and Surrey will give ample proof; and we need go no further than Mr. Birch's picturesque reproduction of "Old London" at the Health Exhibition for good examples. The tower, admitting of more variety, is, perhaps, the most valuable of the two great methods of treating the wall.

Wherever there have been fortifications there have been towers; but as a tower is easier to destroy than anything else, and is also more liable to decay and accident than a lower building, it is hard to say to what extent towers may have prevailed in antiquity. But as far as the evidence goes it may, I think, be accepted as probable that though the use of the tower detached and isolated was not infrequent among the Romans—as, for example, in their tombs—its employment as the central feature of a group of buildings to which it shall serve as adding height and dignity, and the position of which it shall mark, is much more common in Christian architecture than in examples of the styles before the Christian era.

The early church towers were built (as all of them have since been built) partly for belfries, partly for landmarks, but chiefly for ornament; and now we possess in the regular use of the tower a means of imparting loftiness to a building which exceeds the gable in its effect. The tower placed at the crossing of the nave and transepts of a great church is in its most telling position, but west towers and towers at the end of transepts, and even detached towers, are all of them effective, and each has its peculiar use in the production of architectural effects. There is no single element of architecture better illustrated in and near London than the tower. The isolated mediæval fortress tower exists in the keep of the Tower of London and in the castle at Rochester. Perhaps the finest tower possessed by any secular building in Europe is the Victoria Tower of the Houses of Parliament, where also the Clock Tower shows, with equal success, the different proportions and treatment. A plainer secular building, rich in towers of very happy and telling design, is Mr. Waterhouse's Natural History Museum. For a grand central cathedral tower you must go as far as St. Albans, unless you accept the drum and dome of St. Paul's; but a very fine central tower, unhappily somewhat restored, exists at St. Saviour's, Southwark. Some of the modern Gothic churches in London are fine examples in their way. I will only mention Mr. Pearson's church at the foot of Vauxhall bridge as a specimen of a central tower, and Mr. Street's church, near Vincent square, Westminster, with a detached one. Finally, we have a unique series of towers to Wren's churches and those built by his immediate followers; among which the most conspicuous are the west towers of St. Paul's and those of St. Bride's church, St. Clement Danes, St. Mary-le Strand, and St. Martin's, Trafalgar square. I should like, in referring to the tower, to point out to you that it need not be very lofty to be an extremely valuable addition to a building. A low square mass rising about the height of one story above the surrounding roofs is often enough to add dignity without seeming pretentious or ambitious. Such a feature is the Eagle Tower of Haddon Hall. Such are the gate towers of the collegiate buildings at Oxford or Cambridge; and a good modern example is the clock tower at the new Law Courts. Other methods of varying the outline of a wall—as, for example, the use of pinnacles, battlements, or parapets, and dormer windows—will, no doubt, recur to your mind as belonging to this part of the subject. Passing over them, we will now turn for a moment our attention to varying the plan of a wall. One of the first and most effective deviations from the straight wall which we know of is, as I have mentioned, the semicircular sweep which the Greeks used for their theaters, and the Romans after them. We also have the fine elliptical curve of the Roman amphiteaters. The Albert Hall may give you some idea of the rich effects which the perspective of such a wall, and the rapidly varying foreshortening of its spaces, and the curves of its outline produce. Occasionally the polygon is met with in late Roman work. Both forms, the semicircle and the polygon, were constantly used in Christian architecture for the chancels of churches, and in a certain number of cases for baptisteries, and even churches, a fine specimen being the Temple Church, London. Perhaps nowhere has the play of light and shade due to variations in plan been better utilized than in the slender towers which enrich some Romanesque churches, and the more elegant and more elaborate minarets which adorn Mohammedan mosques. The dome of Renaissance churches, as for example the dome of St. Paul's, always opens from a cylindrical wall or drum, which is often a good example of the beauty that may be produced by a wall built on a circular plan.

Another among the many modifications which a wall can receive through variations in its plan is the massing of it into piers, or the fortifying it with buttresses at points where heavy weights or great pressure have to be sustained. This is a necessary result of the system of vaulting upon which Roman and mediæval buildings are to a large extent roofed. Such a vault usually can be sustained as well by a series of piers as by a continuous wall, but the piers must be sturdy enough to resist some lateral strain as well as vertical weight. Out of this necessity grew a great deal of the beauty of the vast halls of Roman baths, the planning of which is full of variety. The same thing differently accomplished meets us in every mediæval cathedral, and culminates in that splendid structural feature, the flying buttress. All these methods are now familiar to us, and are among the modes of rendering walls beautiful as architectural features which are at the disposal of the architect at the present day. The fourth method of architectural treatment is enriching the surface of the wall by the use of architectural features, mouldings, or sculpture; and here we are landed on a subject which might, if there were time, be really indefinitely extended. All I can do is to refer to one or two familiar and striking specimens of this mode of treatment, such as may serve to draw your attention to others which you will meet with as you study buildings.

The exterior of a Greek temple will furnish illustrations of these. If we examine the front of such a temple, as, for example, the Parthenon at Athens, the ablest of all, we find that the outer wall, for the greater part of its height, is really a range of columns, what we may call a discontinuous wall, composed of architectural features, with openings. In Roman buildings you find the same sort of architectural enrichment applied to the external face of a wall as mere decoration, often combined with openings or arcades; and exactly the same treatment was revived in the Renaissance. In most phases of Christian architecture, the column on a large scale disappears, and the openings alone are relied on to produce effect, and these are often enriched, grouped, and made important. Small ranges of columns carrying arches are, however, constantly introduced to enrich the surface of the wall.

As typical examples of this your attention may be direct-

ed to the west front of the cathedral of Poitiers, which is one mass of arcades; to that of Notre Dame, of Paris, and to that of Litchfield Cathedral, both of them rich in lines of arcades, but each of them only a specimen of a large class.

Reverting to our Greek temple, we, in the second place, find its main lines marked by mouldings. The outline of the pediment and its horizontal base, and the division of the architrave and frieze, are each made plain to the spectator by an appropriate effective group of mouldings. A moulding is, in fact, an architect's means of drawing a line on his building. Accordingly, it is usual of buildings in every style to mark the foot of the wall by a moulding, and the top or cornice of the wall by a prominent moulding or group of mouldings; and we constantly find, if the wall is at all a lofty one, that it is further divided into stories by mouldings in the shape of string courses or cornices at appropriate heights. Lastly, in a Greek temple we find the tympanum of the pediment a mass of sculpture. Statues or specimens of carving often marked the summit and the starting points of the pediment, and the frieze is enriched with sculpture, either continuous or in spaces divided from one another by triglyphs.

Here then we have a third and most effective mode of rendering a wall interesting and beautiful—to enrich it with sculpture. There is no architectural style of importance, except the Mohammedan, where carving of animal and vegetable forms of life is not constantly employed for this purpose, and in that style the use of geometrical patterns of the utmost beauty has been carried to such perfection as to prevent one feeling the want of vitality in the decorations. The great sculptures from the Parthenon at Athens—the finest examples of sculpture known—were the decorations of a building. I have already referred to the slabs of alabaster which lined the walls of the Nineveh palaces. The carving on them is full of interest, and gives us the amplest representations of the life of kings and warriors in that country. The finest buildings of the Romans were rich in sculpture, especially in the interior. In the Middle Ages the carving and the sculptures were admirable, sometimes for their spirit, and at others for their finish; and since the close of the Gothic period no really first class building has been deemed complete without statues, or bass-reliefs, or similar architectural sculpture. Enriching the surface of the wall can, we thus see, be accomplished by the use of features, mouldings, sculpture; and, though I have quoted conspicuous examples, these means are equally at the disposal of the architect of humble and unpretending buildings. Features there must be; mouldings it is almost essential to introduce. The work of the sculptor is more of a luxury; but it gives a life and finish to the work with which it is associated that one would never willingly be without.

The last subject which I have to touch upon is the architectural treatment of a wall by means of color, and this subject one approaches with mingled feelings. It is probably the side of architecture where the largest possibilities remain for those who can seize them; but it is also the one where the taste, and let me add the atmosphere, of this country seem to throw obstacles in the path of an artists. Arabs are born colorists, as are Italians. If an Englishman is a colorist, even after a painful education, it is something like a miracle. The external use of color is chiefly confined to the use of colored materials, and here the prevailing colors, at least of natural materials such as stones, slates, and marbles, are half-tones easily harmonized, so that it is difficult to go astray. In Italy the use of marble of two colors in alternate stripes was common in Gothic buildings, and this, I confess, is often carried to excess, but the effect produced when it is done with delicacy is good. An example of the successful use of terra cotta in two colors laid in alternating courses is to be seen in the Natural History Museum, and serves fairly well to illustrate this Italian peculiarity. Methods of using colored materials generally spring up where the materials themselves abound, as, for example, in Auvergne in France, or in Cumberland at home.

The use of cut flints inlaid on patterns in stone is common in Norfolk and Suffolk, as, *e g*, at Norwich, and the picturesque effect of English half-timbered houses is largely due to the contrast of dark wood and white plaster. The use of red bricks, which are employed a good deal in the better class of domestic and secular brick buildings near London, may be cited as an example of the use of a strongly colored material for external work. When we step within, we have the whole range of painting, fresco, mosaic, wall-paper hangings, and even stained glass, added to the possession of a vast series of colored materials in the form of woods stones, marbles, and artificial compounds, that are too perishable, or too precious, or too highly colored for use out of doors. Perhaps the most accessible illustration for the student of the use of color in some great past styles is, or was, presented by some of the courts at the Crystal Palace, though the tones of color they now display, after repairs and repaintings, are not always as harmonious or as correct as those which Owen Jones and Digby Wyatt gave them thirty years ago. The Egyptian court gives a faint copy of some of the simpler schemes used in the interiors of Egypt.

The Pompeian court is very successful, and on the whole very faithful; it gives, in bright weather, no bad idea of the ordinary mural decorations used by the ancient Romans, and revived with much success by Raphael and his school. The Greek and Roman courts are less happy; but the Alhambra court gave an almost perfect reproduction of the most brilliant Moorish wall decoration, and still, though coarsely repainted, gives a fair general idea of the color they so successfully employed. Of the beauty of mediæval coloring, especially with its incomparable enrichment of stained glass, and of the sumptuous splendor of Renaissance interior, I cannot undertake to speak—partly for want of time, partly also because there are few places within reach to which I can direct you in search of specimens—and no words, no engravings, no pictures even, are of much use in conveying an idea of a good colored interior unless you can actually see it for yourselves. I believe the best colored decorations of the present day are in private houses, but there are some churches where very good color is to be seen, and many where there is color not very bad but yet not very good. We moderns—and I think the reproach is as applicable to the French as to ourselves—seem, most of us, to have lost the faculty of color, or, at least, the power of applying it happily to architectural decoration; and if we stumble upon a success, it is with most of us rather more of a lucky accident than a genuine result of forethought and deliberate intention. Here we leave the subject of walls. Those of you who go through the lectures which are about to begin will find that most of the topics just glanced at this evening will receive more careful attention in some part of one or other course. In fact, the wall is so important a portion of a building that there are few questions relating to architecture which do not involve some reference to it. But, whether you go further with me or no, I trust you will go away feeling that there is a good deal to be learned about walls, and a good deal to be mastered before one can quite do justice even to a piece or brickwork, much more to a stone wall. I trust also that when you become wall builders yourselves (as I hope you all will), none of your walls will ever fall down; but that they will all, thanks to your skill and taste, remain strong, secure, and comely, and, let us hope, will be richly decorated in harmonious colors.

THE STANHOPE WATER SOFTENER AND PURIFIER.

THE importance of having pure water for steam-boilers, and the preponderance of impure sources of supply, have led to numerous devices for attaining the desired end of purification, as our columns occasionally bear witness. By purification we mean the withdrawal from the water of all impurities, such as organic matter, the carbonates and sulphates of lime and magnesia, and other salts which form incrustation and scale. In fact, pure water is such as, when evaporated, will leave the boilers, heaters, steam pipes, and feed pipes clean and free from all deposit. The latest invention having this object in view, and which object it successfully accomplishes, is the Stanhope water purifier, the invention of Gaillet & Huet, made by Cordner, Allen & Co., of London. It is constructed of iron throughout, which permits the use of reagents, such as caustic soda, which are not admissible where straining cloths are employed. In the second place, cleaning out is effected by simply opening a series of mud cocks, no labor being required and no portion of the apparatus being removed. But the distinctive feature of the process, and the one which gives it its especial value, is the simple but effective means adopted for inducing the precipitation of the impurities without in any way choking the purifier or retarding the delivery of the water.

A reference to our illustrations will give a good notion of the manner of working, Fig. 1 being a perspective view of a complete apparatus capable of purifying 50,000 gallons per day. The purification takes place in the large square clarifying or precipitating tank, which forms the body of the apparatus, and which is shown separately at Fig. 2, a portion of the casing being removed to show the interior arrangement. Instead of passing downward through filtering screens, which must gradually become clogged and so retard the flow, the water, after mixing with the requisite reagents, enters at the bottom of the tank and circulates slowly and smoothly toward the top, meandering in shallow strata between a number of V-shaped diaphragms inclined at an angle of 45°, which are riveted alternately to opposite faces of the tank as also to the two adjacent sides. All the diaphragms shelve at the same angle toward the same face of the apparatus, where they lead to a series of mud cocks placed in the angle of the V, through which the collected deposit is discharged at intervals. Fig. 3 of our engravings represents a complete apparatus for purifying up to 200,000 gallons per day.

FIG. 1.

FIG. 2.

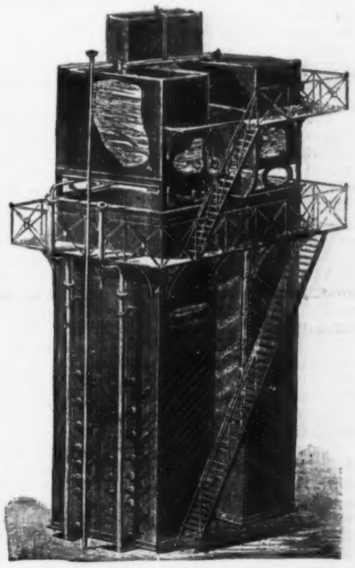


FIG. 3.

THE STANHOPE WATER SOFTENER AND PURIFIER.

The apparatus by means of which the water is mixed with the desired reagents is very simple, and consists of three ordinary tanks, two placed side by side, and a third smaller one placed above them. These are generally placed upon the top of the clarifying tank, as shown in Figs. 1 and 3 of our illustrations, but they may be fixed in any other place that may be found convenient. The smallest or topmost tank contains a solution of caustic soda (or whatever other reagent is necessary), of which the required quantity is run off into one of the larger tanks in which lime has been dissolved in water. The liquid is allowed the requisite length of time to settle, the other large tank being meanwhile in use. The soda-lime or other solution, when clear, is allowed to run off at a regulated rate, and to mix with the water to be purified. The immediate effect of the addition is to render insoluble the substances previously in solution, the result being a precipitate so fine that it takes a considerable time to settle. The turbid water falls, while mixing, through a long pipe, enters the clarifying tank (shown at Fig. 2) at the bottom, and at once assumes an upward motion. As the section of the tank is very large and that of the supply pipe very small, the water naturally rises very slowly and gently, allowing the solid particles to settle almost as if the water were at rest. The purpose of the V-shaped diaphragms will now be apparent. The water has to pass slowly between them in shallow layers, and as the solid particles have but a few inches to fall, they readily settle upon the diaphragms. As the latter are V-shaped, the deposit slides down into the angle, and as that also slopes down toward the side of the tank, the deposit is naturally directed to the mud cocks, through which it is discharged when necessary. The water meanwhile becomes gradually clearer as it rises, and is ultimately drawn off at the top perfectly bright and soft.

The apparatus has been working on a large scale in various parts of England and France, and the recorded experience of the users is that the boilers fed by it need absolutely no cleaning, the absence of scale of any kind being nothing less than remarkable. Engineers who are aware of the waste of coal, loss of time, cost of cleaning, and risk of explosion which are inseparable from scale, will know how to appreciate a thorough preventive, at its full value. We need hardly say that its application is by no means confined to boilers. Wool washers, dyers, bleachers, brewers, and chemists use it with success and benefit, the stated economy effected being in some cases very great. In the circumstances there cannot be two opinions as to the value of the invention, which has a very wide and profitable field before it.—*Iron.*

TELEPHONING WITHOUT WIRES.

By Prof. E. J. HOUSTON.*

I DO not mean to attempt to describe all the varieties of telephones exhibited at the Exhibition, since that would take longer than the time at our disposal. I wish rather to call your attention to a few of the many novelties in telephony which were presented by the various exhibits, and I believe that we can find abundant material if we consider some of the apparatus exhibited by Prof. Alexander Graham Bell and by Prof. Amos E. Dolbear.

The mechanism of the magneto-electric telephone is so generally understood that I need not stop to describe it. This species of telephone, as you are well aware, is a contrivance by means of which speech is readily transformed into electricity, the electricity so produced is transmitted over a conductor, and transformed at the other end of the conductor into speech. The telephone, therefore, is practically a dynamo-electric machine in which the steam engine for driving the same is replaced by the voice. The electricity so produced traverses the conducting wire, and entering a second dynamo, which acts as a motor, produces motions in a diaphragm which result in the reproduction of the original speech.

Without going into any further description of the telephone, permit me to call your attention to some very beautiful experiments conducted by Prof. Bell, which resulted in the discovery by him that the conducting wire, usually employed for transmitting the electric current, could be replaced by a beam of light. This discovery resulted in the invention of an apparatus called by Bell the *photophone*, and now generally known under the name of the radiophone. Noticing a photophone on exhibit in the collection of the Bell Telephone Company, I prevailed on the gentleman in charge of the exhibit to bring the instrument to the Institute, so that I might have the pleasure of showing it to the members and explaining the method by which it is operated.

Before doing so, however, it may be well to briefly review what has been done with apparatus of this character, and in this direction I cannot do better than to call your attention to an elaborate series of experiments conducted by Prof. Bell in connection with Mr. Sumner Tainter, an account of which is published in a paper read before the American Association for the Advancement of Science, in Boston, August 7, 1880.

The experiments carried on by these gentlemen were originally made with a view of studying the causes of the curious sounds emitted when a vibratory beam of light was permitted to fall on certain substances. These experiments were first carried on with the then rare element selenium, but they were afterward extended to other materials which were found to produce the same phenomena. Among some of the substances which they found would emit sounds when vibratory beams of light were permitted to fall on them are gold, silver, platinum, iron, zinc, lead, copper, hard rubber, celluloid, gutta percha, ivory, paper, and wood.

In order to produce these effects, alternations of light and darkness, following each other with a certain rapidity, were permitted to fall on plates of the substances named, when musical sounds were emitted, the pitch of which was dependent on the rapidity with which the light and shadow succeeded one another. By properly modifying these alternations of light and shadow, even articulate speech was thus obtained.

It is not, however, to this method of causing light to produce sound that I wish to call your attention, but rather to

* Comprising the substance of remarks made by request, at the stated meeting of the Franklin Institute, held Wednesday, October 15, 1884.—*Franklin Journal.*

the possibility of using a beam of light in the place of the conducting wire ordinarily used in telephonic communication. In order the better to do this, it may be well to give some little attention to the properties of selenium, as this is the substance now used in connection with Mr. Bell's photophone.

Selenium was discovered in 1817, by Berzelius, while conducting a series of experiments on the refuse of some sulphuric acid works. Noticing a peculiar odor emitted by the refuse, and ascribing it to the then rare metal tellurium, he endeavored to separate this element from the refuse. Without asking your attention to the very excellent work he performed in this connection, I will simply mention that as the result of a series of elaborate experiments made on the refuse he obtained, not the element tellurium for which he was seeking, but an entirely new element which he named selenium.

Selenium, as obtained by Berzelius, is a non-conductor of electricity. There are, however, different forms in which it can be obtained. If selenium is rapidly cooled from a fused state, a form known as the "vitreous variety" is obtained. This variety has a dark brown color, when in thin films, is transparent to ruby red light, and is a non-conductor of electricity. When, however, fused selenium is slowly cooled, a variety known as "crystalline" or "granular selenium" is obtained. This is opaque to light, is of a dull lead color, and is a conductor of electricity.

The conducting power of selenium is, however, exceedingly slight, its electric resistance as compared to that of ordinary metals being enormous. It was the fact of its great electric resistance that induced Willoughby Smith to employ selenium in his system of cable testing and signaling during submersion, for the high resistance at the shore end of a submarine cable. When so employed, phenomena were observed which eventually led to the invention by Mr. Bell of the photophone.

Although the introduction of the selenium resistance at the shore end of the cable readily afforded the high, artificial resistance required, yet Mr. Smith was exceedingly puzzled to find that its value was subject to remarkable fluctuations. Patiently investigating the cause of these variations of resistance, he at last discovered the exceedingly curious fact that the electric resistance of selenium is much less in the light than in the dark. He announced this discovery to the Society of Telegraph Engineers on the 17th of February, 1873. As might naturally be expected, this peculiar property of selenium was at once investigated by scientific men in different parts of the world, and several varieties of selenium, varying very greatly in their conducting power for electricity in the light and in the dark, were obtained. For example, in February, 1876, Dr. C. W. Siemens obtained a variety of selenium whose conductivity was fifteen times as great in the sunlight as in the dark.

Previous to the investigations of Bell and Tainter, the variations in the electric resistance of selenium by light were shown by the use of a galvanometer inserted in the battery circuit in which the selenium was placed. As long as the electric resistance remained constant the needle was motionless; but when light was flashed on the selenium, since a greater electric current then traversed the circuit, the needle of the galvanometer was at once deflected. Now, when Prof. Bell began his investigations on selenium, it occurred to him to replace the galvanometer by a telephone. From his knowledge of this latter instrument he readily appreciated the fact that in order to obtain its greatest sensitiveness it would be necessary to cause a very quick succession of variations in the intensity of light to fall on the selenium; for, in the magneto-electric telephone it is only at the moment of change in the intensity of the current that any audible effect is introduced by the diaphragm. He therefore rapidly varied the alternations of light and shadow by permitting an intermitting beam of light to fall on the selenium resistance. Under these circumstances a musical note was heard, the pitch of which was dependent on the rapidity with which the variations in the intensity of light followed one another. These experiments enabled him to announce on the 17th of May, 1878, in a lecture delivered at the Royal Institution of Great Britain, the possibility of hearing the fall of a shadow.

From these experiments the idea naturally suggested itself to him of employing a beam of light in place of the conducting wire ordinarily employed in telephony.

Now what must we have in order to apply the principles already explained as to the variations in the electric resistance of selenium by the action of light, to permit us to talk along a beam of light? We need a beam of light to replace the conducting wire. We need an arrangement by which this beam of light shall be varied in its intensity by the action of the voice, and a contrivance by which the beam so varied shall be permitted to fall on the surface of a selenium resistance which is included in the circuit of a voltaic battery and a telephone. Under these circumstances a person talking against an apparatus which we will subsequently explain, causes rapid variations in the intensity of the beam of light. These variations being imparted to the beam produce corresponding variations in the amount of current that flows through the circuit. These in their turn produce, in the diaphragm of the telephone, movements which are translated by the ear of the observer into articulate speech.

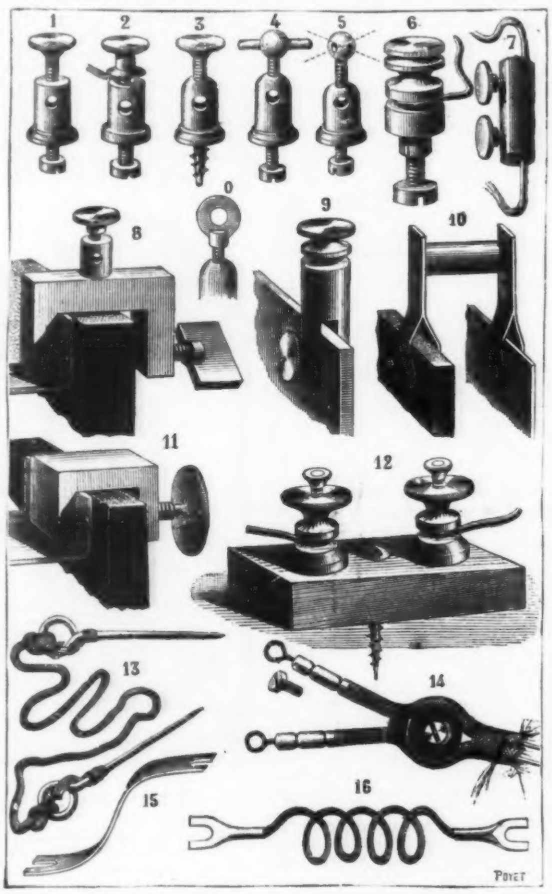
The most important part of a photophone is evidently the selenium resistance. These resistances are generally made in the form of what are known as selenium cells. Previous to the time of Bell and Tainter these cells were not in a condition suitable for use in connection with an ordinary telephone; the least resistance of any selenium cell being, I believe, about 250,000 ohms in the dark. Such cells, of course, could not be used in connection with a telephone. Messrs. Bell and Tainter, however, succeeded in making cells whose resistance is about 300 ohms in the dark, and about 150 in the light. It is such cells that are employed by them in connection with their system of radiaphony.

Messrs. Bell and Tainter attribute their success in lowering the resistance of their selenium cells to the use of substances like brass, that exert a slight chemical action on the selenium. This action, in the opinion of Mr. Bell, prevents the selenium from acting toward other substances somewhat like greasy water does, and so insures the contact of an extended surface instead of a series of minute contacts. The selenium cell we will employ this evening is formed of alternate metallic disks of brass separated by disks of mica, of slightly smaller diameter, the spaces between the brass disks over the mica being filled with selenium. The alternate brass disks are connected together, as are also the selenium disks; that is to say, the selenium cell is coupled in multiple-arc.

Let us now inquire what must be done to the beam of light in order to permit it to be suitably varied in intensity by the action of the voice. As I understand Mr. Bell's invention in the art of articulate radiphony, it consists in the use of an undulatory beam of light in distinction from a vibratory beam. He claims, I believe, that it is not possible to transmit articulate speech by means of a pulsatory beam of light, that is, by means of alternations of light and absolute darkness. What he does is to produce variations in the intensity of the light that correspond with the variations in the amplitude of the sound waves produced by the movements of the plates of the diaphragm. This he accomplishes as follows: a parallel beam of light is permitted to fall on a flat plate of thin glass which is covered with a film of bright metallic silver. This plate is fixed at its edges in a manner similar to the diaphragm of the telephone. If now a speaker talks against the back of the plate, the sound waves set it into vibration and cause it to become alternately convex and concave. These changes, you will readily understand, will result in alternately causing the parallel rays of light in the beam to diverge and converge and thus to illumine the selenium cell more faintly or more brightly, but at no time to cut off all the light from it. In other words, the effect of the voice of the speaker against the plane silvered reflector is to produce undulatory photometric variations in the beam of light that falls on the selenium resistance.

In order that you may be able to see these variations in the photometric intensity, I will illumine a cloud of smoke by means of a parallel beam of light. When now the voice is permitted to fall against the plate, you will observe the very pronounced manner in which the breadth of the beam is altered.

Mr. Wilson, of the Bell Telephone Company, who had charge of the Bell exhibit at the exhibition, has kindly consented to operate the apparatus for me, and I will now show you in actual operation the process of talking along a beam of light. The limits of our lecture room would naturally prevent a fair trial as to the success of the experiment, since



APPARATUS FOR MAKING ELECTRIC CONNECTIONS.

any remark a speaker made at one end of the beam of light could be distinctly heard across the air space by the observer at the telephone. I have therefore connected the telephone by means of a metallic circuit with a room on the floor above, and an observer in that room will be able to hear all that is spoken against the plate in the lecture room.

The light we will use for this purpose is the lime light. Arranging the lenses of the lantern so as to obtain a parallel beam of light, I allow it to fall on the plane silvered mirror before described. When, now, we talk against the plate, the beam of light is caused to vary in the manner we now see, and this undulatory beam falling on the selenium pile, which as we see is placed at the focus of a parabolic reflector, produces corresponding variations in the current that traverses the circuit of the battery, and so permits articulate speech to be reproduced in the telephone.

Another experiment in telephony made at the exhibition may not be devoid of interest. I allude to the experiment tried by Professor Dolbear with his ingeniously constructed electrostatic telephone. This instrument, as you are aware, is not magnetic in its action, and works on a principle entirely distinct from that of the magneto-electric telephone, the vibrations of the diaphragm being caused by the attractions and repulsions produced in two parallel conducting plates. The peculiarity of this experiment consists in the fact that with this instrument we can telephone, not only without wires, but without even a beam of light. Holding a telephone to the ear, and having its terminals not connected with any metallic conductor at all, we can walk around a room, and yet in all positions hear what a person is saying who is talking into the telephone at the other end of the line. When I speak of a room, however, you will understand that I refer to a room of the size of that occupied by Professor Dolbear at the exhibition, which was about eight feet square.

If you regard this experiment as being somewhat incredible, I can assure you of its truth, for I have tried this experiment myself. The phenomenon, however, is difficult to understand; indeed, like many other surprising things in science, it is difficult to explain why such an experiment was not tried sooner; but as we all know, it is those very things that are apparently so simple that require the greatest ingenuity to originate.

The explanation of the phenomenon, as I understand it, would appear to be somewhat as follows: One of the plates already referred to, being connected through the body of the observer to the ground, is thus joined to one end of the telephone circuit; the other plate is connected to the other end of the circuit by a line of polarized air particles. The experiment is simply an exceptional application of the principles of electrostatic induction, and I am not at all sure but what it may be susceptible of a great increase in delicacy, and thus become of considerable commercial value.

MR. OUTERBRIDGE remarked: The very interesting explanation of the photophone is exceedingly clear in every respect, and I think every one in this building will understand just exactly the method by which the action of a beam of light carries sound; but at the beginning there was a statement made, which Professor Houston may have made inadvertently, or it may have been a mere *lapsus linguæ*, and I should be glad to call it to his attention. Professor Houston said a beam of light falling upon a selenium cell or on other metals would cause a sound. Is it actually so?

PROFESSOR HOUSTON: The statement I have made concerning the audible sounds which selenium and other substances emit when a vibratory beam of light is allowed to fall on them, are vouched for by Professor Bell, and will be found in a paper which he read before the American Association for the Advancement of Science, in Boston, in August, 1880. He found that when plates of these substances were simply held to the ear, and light was permitted to fall on them, sounds were distinctly heard. I believe he found that these phenomena were more marked in the case of thin plates of the materials, and ascribed the cause of this circumstance to the fact that the action of the light was a surface action.

DR. WAHL: I would like to ask Professor Houston if any success has been made in interpreting the sounds transmitted by the photophone?

PROFESSOR HOUSTON: It is not all that one might desire, though I could understand, I suppose, all that was spoken; but you will understand that the photophone is an exceedingly delicate apparatus, and in the hurried and necessarily clumsy way in which we have it arranged, we cannot expect to be able to hear everything distinctly, but I could distinctly understand words and distinguish musical sounds.

DEVICES FOR MAKING ELECTRIC CONNECTIONS.

IN the accompanying engraving we bring together the principal arrangements now employed for effecting connections between various electric apparatus.

Fig. 1 shows an ordinary terminal to be fixed to the base of an apparatus. Fig. 2 shows a modification of the former that allows the wire to be either fixed in the eye when it is large enough, or between two flat parts when it is fine or has a flattened form. Fig. 3 shows a terminal provided with a conical screw, and designed to be fixed to apparatus whose under part is not accessible and does not permit of Nos. 1 and 2 being used.

Figs. 4 and 5 show terminals that permit of a secure fastening being effected through a lever. This latter consists either of a small bar fixed permanently to the head of the screw (Fig. 4), or of a nail that may be introduced into apertures in the head (Fig. 5). This is especially adapted to cases where the space is limited, and where there is no need of changing the wire attachments often. Fig. 0 shows a flat terminal head that permits of a secure fastening through flat clamps. Fig. 6 represents a terminal with flat clamp employed especially on telegraph apparatus. It is fixed to the apparatus by means of a screw, as in terminals numbers 1 and 2, and is prevented from turning by means of a snug at the lower part.

When two wires are to be united, the clamp shown in Fig.

7 is used. This consists of a brass cylinder containing an aperture that runs lengthwise through it, and into which the two extremities of the wire are inserted, and held in place by means of two binding screws. Figs. 8 and 11 represent clamps that are used on Bunsen piles for connecting the carbons with the copper plates. Fig. 11 shows an ordinary clamp, and Fig. 9 a terminal for a zinc plate. Fig. 10 represents the clamp employed by Mr. G. Trouve in his bichromate of potash piles for simply and quickly connecting the elements. In certain cases there is need of often substituting one apparatus for another, and of establishing two communicating wires. In electric measurements, for example, the galvanometer is common to several combinations, and it is convenient to have a means of easily making the substitution. To effect this, the two wires of the galvanometer (which is not always easily accessible) are connected once for all with two terminals arranged upon a smaller block of paraffined oak or ebonite (Fig. 12). This latter is itself fixed against a wall, or upon a table, within reach of the experimenter, and it is to the two terminals thus arranged that are successively attached the wires which, at every measurement, must be connected with the galvanometer.

Connections between a movable apparatus and fixed terminals are effected by means of flexible cords or of connecting cords such as the ones shown in Figs. 13, 14, and 15. Fig. 13 represents a flexible cord whose extremities are connected with plugs when perforated terminals (Figs. 1, 3, 4 and 5) are used. Fig. 16 shows the Radiguet attachment, which is especially well adapted for flat clamps (Figs. 2, 6, and 9). Fig. 14 represents the mode of fixing telephone cords. Accidental tractions that may be exerted upon the wire do not act upon the connecting rings, but upon a cylinder of wood held between the two cords and kept in place upon the block by means of a screw. When communications of feeble resistance are to be established, use is made of notched strips of metal like that shown in Fig. 15.—*La Nature.*

THE CREATORS OF THE AGE OF STEEL.

BESSEMER, SIEMENS, WHITWORTH, AND GILCHRIST.

THERE is more of truth than poetry in giving to the century beginning with the year 1850 the name of "The Age of Steel." The metallurgical inventions and discoveries which mark abruptly that period have effected a revolution in the industry of the world. Steel is to us what iron was to our grandfathers; what bronze was to the armies that sat in league before Troy; what stone was to the naked savages that dwelt in the caves of Gaul before the beginning of history. The very web and woof of modern civilization is woven out of steel. The production of steel in 1882 was as great as the crude iron product of 1850. The metal is omnipresent; it has replaced iron, wood, brass, and copper. The rails, ships, cannon, and machinery of the world are steel. The best definition yet given of man is that he is a tool-using animal; his tools are steel, and the tools where with he makes his tools are steel.

As Carlyle says, "We are to bethink us that the epic verily is not Arms and the Man, but Tools and the Man—an indefinitely wider kind of epic. Man is a tool-using animal. Weak in himself and of small stature, he stands on a basis, at most for the flattest solid, of some half square-foot, insecurely enough; he has to straddle out his legs lest the very wind supplant him. Feeblest of bipeds! Three quintals are a crushing load for him; the steer of the meadow tosses him aloft like a waste-rag. Nevertheless, he can use tools; can devise tools; with these the granite mountain melts into light dust before him; he kneads glowing iron as if it were soft paste; seas are his smooth highway; winds and fire his unwearying steeds."

The conquest of the world man is achieving with steel, and who the men were that have put this weapon in the hands of man, Jeans tells us in the book whose title precedes this article.

The two first and greatest inventors in the trade reaped no reward. Dudley in 1618 learned a way to smelt iron with coal, and died in obscurity. Henry Cort, in the middle of the eighteenth century, invented the puddling process, and would have starved but for a pension of £200 given him by Pitt. Honors and wealth, however, were showered lavishly on the bright galaxy of men whose names are enrolled in the list of the creators of the age of steel. The story of their triumphs over matter and circumstance makes one of the most interesting chapters in the history of industry.

SIR HENRY BESSEMER.—Among the French refugees driven to England by the Terror was Anthony Bessemer. A learned and little man, he speedily accumulated a handsome property, the reward of an inventive ingenuity inherited and developed by his illustrious son. Among many other profitable processes the elder Bessemer discovered that an alloy of copper, tin, and bismuth was the best for type metal. His process he kept secret, claiming that the superiority of his type came from the angles at which it was cut. It lasted twice as long as the other types, and sold all over England. The youngest son of this gentleman was Henry Bessemer, born at Charlton in 1813. His first attack upon destiny was made in improving the stamps upon public documents. He invented a stamp which could not be duplicated or detached, which was adopted by the Government, and for which not a penny was ever paid to the young inventor. His next work was a machine for making patterns of figured velvet, a type-casting machine, and a type-composing machine. While working upon this latter machine he was struck by the fact that bronze powder when manufactured sold for 12 shillings a pound, while the raw material cost but 11 pence. The difference he knew must come from the process of manufacturing, a process which he at once began to study. The article came altogether from Nuremberg in Germany, and no one in England could tell him how it was made. For nearly two years he studied this problem, earning success in the end by his infinite industry. He had not learned to have confidence in the patent laws, and he determined to keep his invention a secret. A friend advanced him £10,000, works were erected, the machinery being made in different parts of England. Five operatives were employed, at large salaries, under pledge of secrecy, and the bronze was turned out at a cost of less than 4 shillings a pound. To this day, although forty years have elapsed, no one has surprised the secret. Sir Henry Bessemer has years since rewarded the faithfulness of his workingmen by giving them the factory and the business, and they too have made fortunes out of the trade.

Between 1844 and 1850 Bessemer patented machines for the manufacture of paints, oils and varnishes; for the separation of sugar from molasses; for a drainage pump capable of discharging twenty tons of water per minute; a machine for polishing plate-glass, substituting a vacuum for the plaster bed. Each of these was meritorious as unique, and as profitable as they were ingenious.

This much will show the surprising versatility of the man, and enable the reader to grasp the character that revolutionized modern industry.

The Crimean war turned Bessemer's attention to ordnance; he produced a projectile which rotated without the aid of rifling from the gun, and made many improvements in the guns themselves. The English authorities ridiculed his improvements; the Emperor Napoleon was greatly struck with them, and requested Bessemer to continue his experiments at the expense of France. At one of the subsequent tests Commander Minie said: "The shots rotate properly, but if you cannot get a stronger metal for your guns, such heavy projectiles will be of little use." That remark produced the Bessemer process for making steel. He knew nothing, absolutely nothing, about metallurgy; he had no idea how any improvement was to be made, and yet he resolved to attack this problem of steel making and solve it.

Prior to 1740 the best steel was made in Hindostan, and cost £10,000 a ton. A watchmaker named Huntsman, after a long course of experiments in that year, produced equally good steel, which could be made at £100 a ton, and for a century Huntsman's process had been used without improvement. In the English process before 1740 the bars of iron were heated with a cement of hardwood charcoal dust, which added carbon to the metal, and made what is called "blistered steel." The heating had to be continued several days. This was as yet unfit for forging, and the bars had to be broken into lengths of about eighteen inches, raised to a welding heat, and hammered with a "tilting hammer," a process which produced good steel. Huntsman took the blistered steel, broke it up into bits, put it into crucibles with coke dust, fused the whole, and so made cast steel.

When Bessemer began his work, this process was the only one in use. The iron had first to be melted into pigs, the pigs heated with carbon into blistered steel, the blistered steel broken up and remelted with carbon into steel ingots in crucibles which could not hold more than thirty pounds each. Bessemer's experiment produced first a cast iron better and stronger than any known before.

At the end of eighteen months the idea struck him of rendering cast iron malleable by the introduction of atmospheric air. A great many experiments followed, all of them moderately successful. Mechanical difficulties almost insuperable stood in the way. At last he constructed a circular vessel three feet in diameter and five feet high, able to hold seven cwt. of iron. He bought a powerful air engine, and ordered in a quantity of crude iron. This was a Baxter House, a place to be ever memorable in the history of the steel trade. The apparatus was ready, the engine was forcing streams of air into the openings in the fireclay-lined vessel, and the stoker was told to pour in the iron as soon as it was sufficiently melted.

The metal was turned, and a volcanic eruption ensued; such a blaze of dazzling fire was never seen in a workshop before. Coruscations of fire filled the chamber. The metal flowed down, and the air burst through it upward, breaking away in great bubbles of living glory. A pot-lid hanging over the blaze disappeared in the flame. All this time the air was rushing into the molten mass, and no one dared go near to shut it off. While they were debating the flame died down. Soon the result of this wonderful pyrotechnic could be examined. It was steel! Seven hundredweight of steel made from melted pig without crucible, coke dust, or charcoal. Seven hundredweight of steel born simply of fire and air!

The British Association met in the following week, and Bessemer read a paper describing his process, exhibiting at the same time his results. It was on the 11th day of August, 1856, that this public announcement was made of the new method. The whole industrial world was aroused by the tidings. Bessemer's paper was reproduced in the *Times*, and the iron trade examined the discovery with infinite interest. Experiments were made in a great many foundries, and the sole talk of the hour was the new way of making steel. Within three weeks after reading his paper at Cheltenham, Bessemer had sold £25,000 of licenses to manufacture under his patent. The Dowlais Iron Company was the first to begin the manufacture. Bessemer personally directed the construction of the works. Again the molten iron was poured into the receptacle, again the air blast bubbled through the metal, the gorgeous display of Baxter House was repeated, everything went well, but the result was not steel—it was nothing but a very good cast iron.

Those who had praised the new process now ridiculed it. The failure was inexplicable, but it was a failure, and exactly six weeks after the publication of the article in the *Times* a meeting of iron masters at Dudley condemned the Bessemer process as a practical failure.

The inventor was not dismayed. Patiently and hopefully he set to work to find the flaw that had spoiled his work. A long series of experiments followed before he found the cause of his failure. By a mere chance the iron used on the occasion at Baxter House when steel was made was Blænavon pig, which was exceptionally free from phosphorus. The metal used at the Dowlais works contained this element. Here he found the cause of his failure. He set to work to eliminate the phosphorus by the puddling process, but while doing this there arrived an invoice of Swedish pig iron, clear of the obnoxious substance. Under his original process this yielded steel of such a high quality that he at once abandoned the effort to dephosphorize ordinary iron, and began to manufacture from the Swedish import. Sheffield steel was selling at £60 per ton; he could buy Swedish pig for £7, and turn it into steel at a very small cost.

Steel is pure iron with a small percentage of carbon to harden it. The line of demarkation between steel and iron is a difficult one to trace. Following the discoveries made in India by J. M. Marshall, Bessemer introduced ferro-manganese into his converter, and the pure iron was at once carburized into steel.

The public, however, had lost confidence in Bessemer; he had spent his private fortune, he had made steel, the point was now to sell that steel. Through the assistance of Mr. Galloway, Bessemer bought in the licenses which he had sold, works were erected, and steel produced at a profit at £42 a ton—Sheffield was selling at £60. This argument was unanswerable—the Bessemer process had won, the ironmasters took out licenses under it, and the age of steel began.

The revolution spread over Europe and America; the process was especially popular in Sweden, where the Crown Prince superintended its first trial. In Prussia Herr Krupp, the great cannon maker, agreed to pay Bessemer £5,000 for a license. With Bessemer's papers Krupp applied to the Government for a patent, the patent was refused, and no royalty was ever paid to the inventor. Belgium and France appropriated the new process, and declined to recognize Bessemer.

Bessemer had attacked the problem of making steel for the purpose of having a better gun-metal than any then existing. Accordingly he returned to his experiments with ordnance. Steel cannon were cast with a tensile strength of thirty tons to the square inch, figures much greater than had been reached before. A number of tests were ordered at Woolwich, but through rank favoritism the matter was submitted to Sir William Armstrong, a rival cannon maker, and very naturally an adverse decision was rendered. The Government would not touch the new metals, and Bessemer, for the time being, let the matter pass, concentrating his attention upon the industrial uses of steel, a field large enough for the ambition of any man. In 1861 he induced the London and Northwestern Railroad to put down some steel rails as an experiment. In 1881 these rails were still in good condition—iron rails had to be turned once in nine months. The next step was the substitution of steel for iron in ship-building; the next, an invention of steel projectiles, which were found to penetrate the iron armor of ships as easily as the old iron balls went through wooden vessels. At this time Bessemer was receiving £100,000 a year from his business, but his inventive faculty was not let lie dormant. The best known of his later devices was a ship built with an automatically balanced cabin in order to do away with sea-sickness. This was a theoretical success, but a practical failure. Henry Bessemer's life-work was the production of steel from cast iron; all the other many achievements of his mind were, after all, but side issues. In the first twenty years of the life of his invention he had saved to the industry of the world over a billion pounds sterling—that is, the work of one man did nearly twice as much to build the wealth of the world as the American civil war did to pull it down—indeed, figuring upon the actual saving made, Bessemer's invention had saved enough money to humanity by 1882 to pay for the American civil war, the Franco-Prussian war, the Austro-Prussian war, and the Italo-Franco-Austrian war of 1859. The inventor had been made a knight of the Order of Francis Joseph, he had been given the Grand Cross of the Legion of Honor, but the British Government declined to permit him to accept it. Out of the enormous benefits of his invention there has come to the inventor a fortune for himself. When his patent expired in 1870, he had been paid in royalties £1,057,748. Added to this, his Sheffield works divided in profits during their fourteen years' existence fifty-seven times the original capital, and the works sold for twenty-four times the original capital. In 1879 Bessemer was knighted by the Queen; honors were showered upon him. His services to humanity were recognized at home and abroad. All of the great cities of Europe conferred their freedom upon him, and, what caused the utmost pleasure to the inventor, a town in Indiana whose chief industry was based upon his invention was named for him, assuring him the only immortality that he desires—the constant record of his memory among the men for whom he worked.

SIR WILLIAM SIEMENS.—Next to Sir Henry Bessemer among the creators of the age of steel stands Sir Charles William Siemens, who was the philosopher of the new era, as Bessemer was the inventor. After becoming a thorough student in electricity, Siemens' first exploit which attracted general attention was the invention with his brother of the system of anastatic printing, a process by which any old or new printed matter could be reproduced. This was rather a *succes d'estime* than a money-making discovery, although it brought the young inventors into European notoriety. The method consists in applying caustic baryta to a page of printed matter, changing the ink to a non-soluble soap, and then applying sulphuric acid to precipitate the stearine. The paper was then pressed into a slab of zinc, making an intaglio from which copies could be easily taken.

Siemens next perfected a method for greatly increasing the heating power of furnaces by compressed air, the results being of immense practical value to the trade. The very high temperature which he was thus able to gain at a small cost of fuel naturally was applied to the working of steel. His method is called the "open hearth process." In this process the charge consists of pig iron, which is placed on the bottom and around the sides of the furnace. Melting requires four or five hours, then the pure ore is charged cold into a bath in quantities of four and five hundredweight. Violent ebullition ensues, and when this ceases more ore is put in, the object being to keep the boiling uniform. Spiegeleisen or ferro-manganese is added, and the charge is cast. The result is steel. Siemens' first improvement was a rotating furnace, in which coal and iron are put together, and mixed and heated so thoroughly that the result is all that could be desired. So thorough is the process that the hitherto irreducible iron-sands of New Zealand and Canada can be worked to a great profit.

Coming into direct competition with the Bessemer product, the open-hearth steel has held its own, its consumption in the United Kingdom rising from 77,500 tons in 1873 to 436,000 in 1882. The Landore-Siemens Company rolls the armor plate for the British Admiralty, and the steel has been found to be even better than the Bessemer for general shipbuilding. In 1883 one-fourth of the total tonnage of new ship-building was built of Siemens steel.

Sir William Siemens and his brother, Dr. Warren Siemens, of Berlin, have been called the pioneers of modern electrical research. The dynamo machine is theirs, and much of the development of the electric light. Henry Siemens has put on record a series of experiments in electro-horticulture which show astonishing results. In the hostile English climate he has produced ripe peas by the middle of February, raspberries on March 1st, strawberries February 14th, grapes march 10th; bananas and melons showed similar results.

The German electric railway is one of the enterprises of the Siemens. They are the builders—the creators—of the Indo-European telegraphs, reaching from London to Teheran, in Persia. The history of this enterprise, with its dangers braved and its difficulties overcome, is one of the most interesting of this interesting book.

The Siemens laid the first submarine cable in 1847 from Deutz to Cologne, covering their wires with gutta percha. The services of Sir William Siemens to science as well as to the useful arts cannot be too highly appreciated. Besides his industrial triumphs, here constructed our theory of heat. Wealth and honors came to him, but in the midst of his career he was cut down. An accidental fall on a London pavement, November 5, 1883, ruptured the nerves of his heart, and he died a fortnight later, his death being mourned as a national loss in England and Germany.

SIR JOSEPH WHITWORTH.—Joseph Whitworth's first industrial exploit was the production of true plane surfaces in metals automatically, an achievement perfected in 1840. The old method was grinding with emery powder and water. He planed the metals with a steel plane. "So exactly can surface plates be made by his apparatus, that if

one of them be placed upon another, when clean and dry, the upper will seem to float upon the under, without being actually in contact with it, the weight of the upper plates being insufficient to expel except by slow degrees the thin film of air between their surfaces. But if the air be expelled the plates will adhere together, so that by lifting the upper one the lower will be lifted along with it, as if they formed one plate."

Whitworth was essentially a tool-maker. No sooner had he perfected the plane, with its immense effect upon English industry, than he attacked the screw. His system of screws is now adopted all over the civilized world. Following up his improvements, he recognized the necessity for a more exact measuring machine than any then in existence, and supplying this want he devised a machine which would measure distinctly and practically to the 40,000th part of an inch, and theoretically to the 1,000,000th. To show to what exactness this was brought, we quote his own words in an address at Manchester in 1857: "Here," said he, "is an internal gauge having a cylindrical aperture 0·5770 inch diameter, and here also are two solid cylinders, one 0·5769 inch, and the other 0·5770 inch diameter. The latter is 0·0001 of an inch larger than the former, and fits tightly in the internal gauge when both are clean and dry, while the smaller 0·5769 gauge is so loose in it as not to appear to fit at all. These gauges are finished with great care, and are made true after being case-hardened. The effect of applying a drop of fine oil to the surface of this gauge is remarkable. It will be observed that the fit of the larger cylinder becomes more easy, and that of the smaller more tight. . . . It is thus obvious to the eye and the touch that the difference between these cylinders of one ten-thousandth of an inch is an appreciable and important quantity, and what is now required is a method which shall express systematically and without confusion a scale applicable to such minute differences of measurement." The Whitworth gauges have been adopted by the Government as standards of measurement.

The accuracy in mechanical processes rendered possible by Whitworth's inventions bore its first proof in a direction which the inventor little expected.

England was engaged in the Crimean war, and the Enfield rifle, a hand-made weapon, was the arm of her forces. It became necessary to have these guns in large quantities, and the burning question of the hour was how to make these rifles by machinery. The science of projectiles was then entirely empiric. Some guns shot well and some shot ill, but why these were good and those bad no one knew. Whitworth went before a Parliamentary committee, and told it that until the data of rifling were established good machine made guns would be impossible. It was necessary to find out what made an effective gun by continued experiment before anything else was done.

England needed a million rifles. To make these by the processes then in use would have taken Birmingham twenty years. It was agreed that the Government should bear the expenses of Whitworth's experiments.

A gallery was set up at Rusholme, 500 yards long, furnished with tissue paper screens in order to track the bullets throughout their flight, and with sliding targets. The experiments began in March, 1855. The Enfield rifle had a bore of 0·577 inch, and the rifling had one turn in 78 inches. The first result was that in every particular the Enfield was found to be wrong. Whitworth made barrels with one turn in 60 inches, one in 30, one in 20, one in 10, one in 5, and one in 1 inch. To be brief, he determined conclusively that the best rifle had one turn in 20 inches, a minimum diameter of 45 inches, and a rounded hexagonal instead of a circular bore. After beating all other guns at short ranges the Whitworth rifle had a deviation of about 4·62 feet at 1,400 yards. The Enfield could not hit the target at all. With a steel bullet Whitworth's rifle perforated plates of iron half an inch thick at an obliquity of fifty degrees, and easily passed through thirty-four half-inch elm boards.

Applying the same principles to artillery, Withworth devised a gun which threw two and one-fourth hundredweight of iron six and a half miles.

To such a great superiority did he bring artillery, first by his invention of compressed steel, next by making the guns breech-loading, and finally by increasing the size of the powder chamber, that it began seriously to be doubted whether any armor could be made able to resist the crushing force of the square headed Whitworth projectiles. Whitworth himself attacked the new problem, and in 1877 prevailed. He made plates of compressed steel, built in hexagonal, each of which was composed of a series of concentric rings around the central disk. The rings prevented the spreading of a crack beyond the one in which it occurred. Of this material a target was composed nine inches thick, supported by a wood backing against a sand bank. In front a horizontal iron tube was put to receive the fragments of the shot. Against this target a Palliser shell weighing 250 pounds was fired point blank from a nine-inch gun, with fifty pounds of pebble powder, at a distance of thirty yards. This shell would have passed through twelve inches of ordinary armor; against the new target it was shattered into innumerable fragments. The target was drawn back eighteen inches into the sand. The fragments of the projectile, escaping at the end of the tubes, continued their rotation in such a manner as to cut through the planks in front of the displaced target. The only piece that survived the shock was a flattened mass of eight pounds, formed from the apex of the shell and left embedded in the target, where it had made an excavation of eight inches in diameter, and four-tenths of an inch deep in the deepest part. The ring which received the shot was not cracked.

This experiment alone effected a revolution in naval armament.

There is not room here to speak of Sir Joseph Whitworth's eminent services to the cause of technical education. He has devoted a large part of the great fortune won by his inventive genius to the founding of schools and scholarships for the benefit of young men desiring to explore the wide field of mechanical industry.

Sidney Gilchrist Thomas.—It will be remembered that the Bessemer process failed after its first success, and that the reason of that failure was the presence of phosphorus in the pig iron. Such an insuperable obstacle did this present that Bessemer gave up the problem, and went to Sweden for his pig. To Mr. Sidney Gilchrist Thomas belongs the honor of discovering a means of getting rid of this obnoxious element. Acting upon his idea, he and his cousin Mr. Gilchrist, the first twenty-six, the latter twenty-five years old, conducted an exhaustive series of experiments to find a base with which phosphorus would unite. A base is the name given in chemistry to any element for which an acid has affinity. At last they made bricks of lime and magnesia, which they subjected to an intense white heat, when they became hard as flint. With these bricks, which were a base, they lined their converters, the melted pig iron was poured in, and the phosphorus at once left the metal and attached itself to the bricks. A quantity of lime is added to the run, and the result is a thoroughly dephosphorized iron.

The news of the new process spread through Europe, and to show how greatly the invention was appreciated, the following circumstance is detailed: A Continental iron master called on Mr. Thomas at 7:30 one April morning to arrange for terms for the use of the patent. Just as they were concluded, a telegram was handed to Mr. Thomas, stating that another iron master from the same district was coming to arrange terms. The first visitor had secured a monopoly, and the second man was too late. Both of the iron men had come over on the same boat; one had driven straight to the patentee on landing, the other had gone to get his breakfast.

Before the process was three years old it was the means of producing half a million tons of steel per annum.—*Globe-Democrat.*

LIVISTONA AUSTRALIS.

Under the name of Corypha australis this palm has long been cultivated because of its ornamental characters, both when small and when grown to the dimensions of the specimen represented in the adjoining woodcut, and which is now growing in the Jardin des plantes, Paris. In botanical gardens, and especially in the Royal Gardens, Kew, L. australis is to be seen as large and as luxuriant in health as it ever is in the woods of tropical Australia where it is a native. We owe the introduction of this useful palm to a somewhat novel circumstance. In his "Popular History of Palms" Seemann says: "When Allen Cunningham, the king's botanist, was in New Holland, he sent a case with living plants to the Royal Gardens, Kew, which on being disturbed was found to have, instead of the crocks usually placed at the bottom of such cases for drainage, seeds of a palm, nearly all in process of germination. Cunningham's attendants, too indolent to look for the crocks, had substituted the seeds of the Livistona australis, which happened to be more handy. These young plants were carefully nursed, and one of them has now become one of the gems of the collection of palms at Kew; another adorns the chief conservatory at the Royal Garden, of Hanover; and again another at the

LIVISTONA AUSTRALIS.

Crystal Palace, at Sydenham." Since Seemann wrote, the Kew specimen has been removed, owing to its having reached the top of the palm house. This was, however, replaced by another which in its turn will have to be sacrificed, owing to its height. L. australis is a fast growing palm, soon developing into a noble tree, as is seen in the size of the Kew specimens, several of which rear their massive heads of shining green fan-shaped foliage, supported on straight cylindrical rich brown stems, high above the other palms. For decorative purposes and for cultivation in small stoves this palm is, when young, one of the best and most useful.

This along with another equally useful palm, viz. L. chinensis (Latania borbonica), is grown in thousands in Continental nurseries, and a large proportion of those are annually imported by London nurserymen to be sold to the decorator, etc. Very young plants in 6-inch pots of L. australis make good table plants, their little hand, like leaf blades, supported on semi-erect, prickly stalks, and so arranged as to form a graceful pyramid of dark green foliage, being effective when thus employed. L. chinensis is a little straggling or, as some say, ragged, when in a small state, and is not therefore perhaps quite so useful as the other, at least for table decoration. All the Livistonas are, however, really serviceable garden palms, all being palmate, graceful, both when small and when large and hard enough to stand a good deal of rough usage with impunity. Seeds are imported in plenty from various tropical countries, where these palms are now established and fruit freely, and these soon germinate if sown in a warm house, after which liberal treatment in the matters of soil, water, and warmth will soon make the seedlings into plants of useful size, when they should be gradually hardened off, so that if desired they may be used as green house plants or for the decoration of rooms, etc.—*The Garden.*

THE LUMINOSITY OF LUCIOLA ITALICA.

This insect, belonging to the family of the Lampyridæ, is very abundant in the neighborhood of Bologna. S. C. Emery has taken the opportunity of submitting them to a thorough examination, both as regards the anatomical structure of their luminous organs and as to the chemico-physiological process upon which the production and emission of light depend. His observations were much interfered with by the unfavorable character of the weather during the summer of 1883, so that only the anatomical part of his researches can be regarded as completed.

According to his observations, as recorded in the *Zeitschrift für Wissenschaftliche Zoologie*, the luminous organs consist of continuous plates, consisting of single lobes in which the terminal ramifications of the tracheæ, the tracheal capillaries, open without communicating with each other.

The male Luciolæ gave out light in two distinct modes: in the night, when they are brisk and fly about, the light increases and decreases at short regular intervals, so that it seems to twinkle. If one of them is caught flying, or disturbed in its rest by day, it shines less than at the maximum of its intensity when on the wing, but without intermission. It is remarked, however, that the luminous plates do not shine uniformly over their whole extent, but that sometimes one spot and sometimes another glows more strongly. If such a specimen is examined under the microscope we perceive, on a dark background, bright luminous rings, which are not, however, uniformly brilliant, but display certain more intense points, which flash up and again disappear, or continue to shine on faintly for a time, reappearing afterward in full splendor. These changes take place without any regular succession.

Signor Emery concludes that the luminous combustion takes place on the surface of the parenchymal cells, but not in their substance. These cells probably secrete the luminiferous matter, which is taken up by the terminal tracheal cells, and is burnt by means of the oxygen encountered in the tracheal capillaries. Emery does not consider that the emission of light is a sexual attraction for the females, which are rarer. He suspects that it rather serves to deter insectivorous nocturnal animals.—*Jour. of Science.*

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